AD-A015 974

ENERGY DEMAND AND RESOURCES OF JAPAN. VOLUME I

K. Dance, et al

Science Applications, Incorporated

Prepared for:

Rome Air Development Center
Advanced Research Projects Agency

August 1973

DISTRIBUTED BY:

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National Technical Information Service
U. S. DEPARTMENT OF COMMERCE

ADA015974

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RADC-TR-74-39, Volume I
Final Technical Report
August 1973

ENERGY DEMAND AND RESOURCES OF JAPAN
Volume I

Science Applications, Incorporated

Sponsored By
Defense Advanced Research Projects Agency
ARPA Order No. 2339

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Rome Air Development Center
Air Force Systems Command
Griffiss Air Force Base, New York

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER RADC-TR-74-39 Vol I of II	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Energy Demand and Resources of Japan, Volume I		5. TYPE OF REPORT & PERIOD COVERED Final Report, March-August 73
		6. PERFORMING ORG. REPORT NUMBER SAI-73-550-AR
7. AUTHOR(s) K. Dance, R.B. Ryan, J.F. Schneider		8. CONTRACT OR GRANT NUMBER(s) F30602-73-C-0159
9. PERFORMING ORGANIZATION NAME AND ADDRESS Science Applications, Incorporated 1701 North Fort Myer Drive, Suite 908 Arlington, Virginia 22209		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 23390001
11. CONTROLLING OFFICE NAME AND ADDRESS Advanced Research Projects Agency 1400 Wilson Boulevard Arlington VA 22209		12. REPORT DATE August 1973
		13. NUMBER OF PAGES 116
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) Rome Air Development Center (IRRC) Griffiss AFB NY 13441		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) N/A PRICES SUBJECT TO CHANGE		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Japan; Energy; Coal; Hydroelectric Power; Petroleum; Gas; Nuclear Power; Technology Transfer; Geopolitical Scenarios		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The objective of this study was to prepare projections of Japanese energy demands through the year 2000, and to identify potential sources of conflict which might arise as Japan attempts to secure her needed energy supplies. In addition, potential areas of technology transfer to Japan which could have a stabilizing influence on the world energy situation are identified.		

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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Volume I

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Contractor: Science Applications, Incorporated
Contract Number: F30602-73-C-0159
Effective Date of Contract: February 1973
Contract Expiration Date: August 1973
Program Code Number: 3F10

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This research was supported by the Defense Advanced Research Projects Agency of the Department of Defense and was monitored by Clarence K. Davis RADC (IRRC), GAFB, NY 13441 under Contract F30602-73-C-0159.

PUBLICATION REVIEW

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Section 1

SUMMARY

1.1 Technical Problem

As made evident in the popular press and in studies conducted by almost every government agency, the U.S. (and the world) is approaching an energy crisis. The U.S. currently consumes energy at the rate of 17.5 x 10^{15} kilocalories per year and projections for the year 2000 indicate a consumption of 40 x 10^{15} kilocalories. At present rates of exploitation U.S. reserves of oil and natural gas could be depleted by that time; coal and nuclear power would be the principal sources of energy. This situation can be expected to have its impact on the Department of Defense, both in terms of DoD as a consumer of energy and in relation to the potential impact of the responses of other nations to their own energy crises on U.S. security. This report documents a study which addressed the second of these two areas — namely the projected energy demands and resources of Japan and the potential impact of Japan's reactions to an energy shortage on the U.S.

Japan now has a GNP of $270 billion a year which has jumped from a level of $6 billion 25 years ago; prior to the 1971 recession it was rising at an annual rate of 13 percent. Japan's energy requirements are considerable (3.2 x 10^{15} kilocalories in 1971), and they are increasing at a rate twice that of the U.S. Moreover, Japan has few domestic sources of energy (mainly hydroelectric power which is almost saturated) and so is vulnerable to foreign pressures as she seeks to provide for future energy demands.

The Japanese Government has recognized this situation and has given the Ministry of International Trade and Industry (MITI) the responsibility of developing plans for assuring adequate energy supplies. However, energy planning efforts are not confined to that one agency; Japanese businessmen and government officials are acutely aware of the dependence of Japan's economic well being on a stable supply of energy and are engaged in far ranging activities in exploration, development, and research to secure adequate energy supplies both for now and into the next century. Among other things, Japan is negotiating with the Soviet Union for Siberian oil, is participating in a U.S./Soviet $7 billion trade agreement for Soviet natural gas, and has been vying for Alaskan oil. In the nuclear field Japan has agreements for fuel and/or joint research with the U.S., Great Britain, France, and Australia. Despite this planning, problems such as the near- and mid-term dependence on foreign oil and long lead time involved in installing nuclear reactors remain.

The objective of this study was to prepare projections of Japanese energy demands through the year 2000, and to identify potential sources of conflict which might arise as Japan attempts to secure her needed energy supplies. In addition, potential areas of technology transfer to Japan which could have a stabilizing influence on the world energy situation were to be identified.

Volume II of this report contains supporting appendices which discuss in detail the five major energy resources — hydroelectric, coal, oil, gas, and nuclear power.

1.2 General Methodology

The study relied heavily on Japanese documents which address Japan's efforts to secure sufficient energy supplies and which contain energy demand projections. The principal sources were prepared by the Ministry of International Trade and Industry, the Institute of Energy Economics, and the Research Institute of Mitsui Corporation. While independent projections from basic data were not prepared, SAI did prepare detailed estimates of the most likely course of energy demand growth in Japan (base case) and estimated bounding high and low cases. These projections were developed primarily from existing Japanese projections which were modified and shifted in time on the basis of information developed during the course of this study (see Volume II). The fact that the numbers which appear in this report are often expressed to three or more significant figures results from the attempt to maintain consistent supply/demand energy balances and should not imply a corresponding precision in the data base from which they were derived.

Section 2 contains a discussion of the base energy demand projections beginning with a general overview of Japan's energy requirements. In Section 3, ranges of energy demand which depend on different assumptions of economic, political, and social conditions are described. Section 4 contains detailed supply/demand energy balances at 5-year intervals through the year 2000. Geopolitical scenarios which could evolve into conflicts as Japan looks worldwide to find and guarantee future energy resources are identified in Section 5. Section 6 examines potential areas of technology transfer to Japan.

1.3 Study Results

1.3.1 Base Case Energy Demand Projections

The base case projections of the supply of energy Japan will require through year 2000 are summarized in Table 1.1. Highlights of the projections for the time period 1971-1985 are as follows:

- Between 1971 and 1985 Japan's energy demands will grow at a faster pace (7.5 percent per year) than is forecast for the United States (4.2 percent per year). By 1985 Japan's energy requirements in relation to those of the United States will be:
  - Total energy requirement will be slightly less than one-fourth of that of the United States.
  - Per capita energy demand in Japan will be about 52 percent of that in the United States.
- Japan's reliance upon imports for her energy requirements will continue to grow. Imported energy sources which now account for 85 percent of total energy requirements, will account for 94 percent of total energy requirements by 1985.
- Oil is presently the major energy source for Japan and will remain so through 1985. The fraction of total energy accounted for by petroleum will decrease slightly from 73 percent in 1971 to 72 percent in 1985, but absolute requirements for oil will increase rapidly. The potential crisis in meeting this increasing oil requirement is characterized by the following facts:
  - By 1985 Japan's requirements for oil will nearly triple from present levels, going from the equivalent of 250 x 10^6 kiloliters/year in 1971 to 650 x 10^6 kiloliters/year in 1985.
  - The above increase in oil requirements translates into construction requirements for 18 new oil tankers of 200,000 dwt equivalent each year until 1985.

Table 1.1. Projection of Required Energy Supplies (Base Case)

Supply Source	Energy Demand (10^{15} kilacalaries)				Percent of Total Energy			
	Actual	Projected			Actual	Projected		
	1971	1980	1990	2000	1971	1980	1990	2000
Domestic Supply								
Coal	0.218	0.22	0.22	0.30	6.8	[illegible]	2.4	2.2
Hydrapawer	0.212	0.23	0.26	0.26	6.6	4.2	2.8	1.9
Gas	0.027	0.02	0.05	0.10	0.8	0.4	0.5	0.7
Oil	0.008	0.01	0.01	0.02	0.2	0.2	0.1	0.1
Wood	0.014	0.02	0.02	0.01	0.4	0.4	0.2	0.1
TOTAL DOMESTIC	0.479	0.50	0.56	0.69	14.8	9.1	6.0	5.0
Imported Supply								
Oil	2.348	4.01	6.35	8.41	73.0	73.0	68.3	61.0
Coal	0.362	0.44	0.66	0.95	11.2	8.0	7.1	6.9
Gas	0.013	0.08	0.13	0.24	0.4	1.5	1.4	1.8
Nuclear Fuel	0.020	0.47	1.60	3.50	0.6	8.5	17.2	25.4
TOTAL IMPORTED	2.743	5.00	8.74	13.11	85.2	90.9	94.0	95.0
TOTAL SUPPLY	3.223	5.50	9.30	13.80	100.0	100.0	100.0	100.0
Note: Energy far Electricity	0.767	1.65	3.33	5.57	23.8	30.0	35.8	40.4

- Coal requirements for the iron and steel industries of Japan will continue to grow, but the fraction of total energy supplied by coal will drop from 18 percent in 1971 to 10 percent in 1985. Domestic production of coal will remain essentially level as will consumption of coal in thermoelectric generating plants. Increases in coal will come almost entirely from increased imports of coal for the iron and steel industries.

- Demand for electricity in Japan as a fraction of total power will increase slowly between 1971 and 1985, going from about 24 percent in 1971 to about 29 percent in 1985. The three major sources of energy for electricity generation are:

  - Hydropower. Hydropower will increase only slightly and will account for a decreasing share of electrical power.

  - Nuclear. Nuclear power will increase very rapidly, but by 1985 will constitute less than one-half of the total generated electrical power and only 13 percent of total energy in Japan. This increase in nuclear power although rapid, will not greatly affect the need for petroleum.

  - Thermal. Coal inputs to electrical generation will remain relatively stable which means a decreasing fraction of electricity generated by coal. Petroleum requirements for electrical generation will increase as oil continues to account for nearly half of the total energy input for electrical generation.

- Liquified Natural Gas (LNG) imports will increase nearly tenfold, but LNG will be used only for specialized uses and will continue to account for only a very small fraction of total energy (1.2 percent by 1985).

Beyond 1985 the Japanese economy is expected to increasingly shift from an industrial emphasis to a consumer emphasis. Growth rates can be expected to taper off and to assume characteristics similar to those of the United States at present. Environmental concerns and saturation demand effects, coupled with the projected zero population growth in Japan by 2000, can be expected to result in a level off of energy demand. Based on the above factors, the SAI base case projection indicates the following for the period 1985 to 2000:

- Energy demand growth rates will slow beyond 1985, and per capita energy demand will begin to level off sometime soon after 2000 to about 143 x 10^6 kilocalories/year. Per capita demand in the United States is projected to level off by 2000 to about 180 x 10^6 kilocalories/year. The ultimate per capita energy demand will be nearly five times the present demand in Japan, and will be about 50 percent greater than present per capita demand in the United States.

- Beyond 1985 imports will continue to account for about 95 percent of total energy demand, but nuclear fuels will account for an increasing fraction of imports and fossil fuels imports will be reduced to 69 percent of total energy needs by 2000

- Oil will remain the main energy supply through 2000, but the percent of total energy supplied by oil will drop from 72 percent in 1985 to 60 percent in 2000. The slowdown in the rate of increase of Japan's energy demand coupled with an increasing nuclear energy supply will result in a slower rate of increase in the need for oil. Oil requirements between 1985 and 2000 will increase by about 50 percent going from 650 x 10^6 kiloliters/year in 1985 to 980 x 10^6 kiloliters/year in 2000. *

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* Based on an energy content of 9400 kilocalories per liter of crude, the following conversion factors may be applied to the data in this report:
1 kiloliter = 6.29 barrels
1 kilocalorie = 6.69 x 10^{-7} barrels
1 kilocalorie/year = 1.88 x 10^{-9} bbl/day

- Coal requirements will continue to grow, but at a reduced rate, and the fraction of total energy supplied by coal will hold about constant at 10 percent. Domestic production will increase but will remain less than one-third of total coal requirements.

- Demand for electricity in Japan will continue to grow rapidly and by 2000 electricity generation will account for 39 percent of total energy. Almost all new electrical capacity installed between 1985 and 2000 will be nuclear, and nuclear fuel will account for nearly all base load generation by 2000.

- LNG imports will continue to increase, but LNG will continue to account for a very small fraction of total energy needs.

1.3.2 Geopolitical Implications of Japan's Energy Demand

It is difficult to postulate situations arising directly from the energy crisis which can lead to armed conflict of consequence. A possible exception is in the Middle East, but here it is difficult to separate an energy-related scenario from yet another manifestation of the Arab-Israeli conflict. The energy crisis seems to offer numerous opportunities for severe economic competition and minor skirmishes; the major powers, however, are developing a sufficient number of options that they will not be dragged quickly into war. Japan herself has limited armed forces and traditionally has selected the option to underwrite foreign Japanese business losses rather than attempt to defend them with force. Because an energy crisis would strike close to the economic heart of the countries involved, even minor skirmishes could have serious consequences and potential trouble spots should be carefully watched.

The geopolitical implications inherent in Japan's determination to assure energy sources for her industrial and commercial future are based on both economic and political motives. Economically Japan would prefer to develop alternative sources of petroleum which are politically stable and geologically viable, keep a firm hand on the well-head, refinery, and transportation process, and continue to route her tankers through the Straits of Malacca. Economically Japan is prepared to outbid potential rivals for scarce petroleum supplies and has the resources to do so. Politically Japan will tend to support whatever side in competing territorial claims that offers Japan an assured source of petroleum and the ability to acquire it at the most favorable terms. Politically, Japan will do nothing to offend her Arab suppliers of oil. Finally, both economically and politically, Japan may be unable to sidestep the growing restrictive policies of nationalization that are developing worldwide and the growing demands of the OPEC nations, and so may not be able to completely avoid confrontation and denial of supply.

Section 5 examines Japan's relations with Persian Gulf countries and discusses Persian Gulf-to-Japan oil transportation in terms of tankship requirements, tanker routes, and a potential trouble spot — the Straits of Malacca. The effect of Japan's energy requirements on her relations with the Soviet Union, the Peoples Republic of China, and the United States is also examined, and a final subsection identifies potential conflicts arising from offshore oil exploration.

1.3.3 Potential for Technology Transfer to Japan

The subject of technology transfer was approached in terms of attempting to lessen Japan's dependence on petroleum. Anything which might reduce Japan's need for oil would have the primary potential benefit to the U.S. of helping to maintain economic and political stability. Prospects for such technology transfer include:

- coal gassification
- high temperature gas reactors for direct process use of n'cl energy
- geothermal energy systems
- fusion power production

In addition to the areas identified above which deal directly with energy production, there are several potential technology transfers in energy-related fields which might help Japan to maintain her industrial growth. Examples include:

- coal sulfur emissions control
- uranium enrichment technology
- radioactive waste disposal
- environmental technology

Section 2

BASE CASE ENERGY DEMAND PROJECTIONS

2.1 General Overview

Japan is fully aware that, on her present course of industrial expansion and growth, an energy crisis is incipient. The Ministry of International Trade and Industry (MITI) is the cognizant government agency charged with the responsibility of formulating appropriate policies to minimize the impact of a potential energy shortage upon Japan's industry, trade, and commerce. The situation is exacerbated by the fact that Japan is highly dependent upon imported petroleum and is expected to remain so for the foreseeable future.

The current situation finds four major sources of energy used in Japan. These are:

- Hydroelectricity: Locally generated and completely dedicated to Japan's electric power industry, hydroelectric power was the first major contributor to Japan's industrial renaissance, but is being displaced from a primary to a secondary peak power reserve role.

- Coal: Domestic sources of coal have been used to fuel Japan's thermoelectric power plants and imported coal has been used in the metallurgical industry. It is now being displaced as a primary contributor to the electrical power industry but maintains a strong position, primarily from imported sources, for the metallurgical industry.

- Petroleum: Petroleum is the key to Japan's present industrial economy and is the area in which, if Japan is to undergo an energy crisis, shortages will first become apparent. Petroleum serves three major elements of the Japanese economy. It goes directly to industry and transportation; it goes directly to the generation of additional energy, mostly electrical power; and it furnishes the raw materials for Japan's petrochemical industry. Japan's petroleum reserves are minimal and 99 percent of her petroleum requirements must be imported. No new local sources, even if discovered, are expected to alter this significant imbalance.

- Nuclear power: Like hydroelectric power, nuclear generation is a "dedicated source" for the electric power industry. Although still in its infancy, nuclear power is expected to burgeon and to supplement imported petroleum in meeting Japan's demands for electrical power.

Japan is currently highly dependent upon imported petroleum. There has been no tanker shortage to date, and Japan's shipbuilding capacity appears adequate to meet future demand. Japan's 1971 petroleum imports, the real key to Japan's potential energy crisis, were:

- 85 percent from the Persian Gulf area of the Middle East
- 13 percent from Indonesia and surrounding Southeast Asian territorial waters
- Less than 1 percent from the USA (although Japan has been planning to purchase Alaskan oil, a fact not generally known in current discussions on the subject)
- Slightly more than 1 percent from producing fields in West Africa and Libya
- Less than 1 percent from South American (although a series of trans-Andean pipelines either operational or under construction could change this picture significantly in the next decade)
- Less than 1 percent from the USSR.

Japan is taking steps to control the complete flow of oil from wellhead to consumer by: actively participating in petroleum exploration; forming joint ventures, worldwide, with existing petroleum production and exporting companies; expanding her own tanker fleet; and lessening her dependence upon Persian Gulf oil.

The official Economic and Social Development Plan adopted by the Japanese government calls for continuing through 1975 the present economic policy of relatively high capital expenditures in comparison with spending for consumer goods. The adoption of such a plan and related policies is intended to result in a continued rapid increase in Japan's economy, with the probable effect of an even faster increase in Japan's total energy demand. Between 1975 and 1985 the Japanese economy can be expected to slowly shift toward a Western European or United States type economy, which is more oriented towards private consumption. Such a shift, coupled with increasing environmental concerns, should begin to slow the rate at which the Japanese economy expands. However, through 1985 the Japanese economy, and the resultant energy demand, can be expected to continue to increase and at a faster rate than is projected for the United States.

2.2 Background

Japan's emergence as an industrial "superpower" has had worldwide commercial and economic implications, particularly in the past several years. Yet Japan is not newly arrived upon the scene as a major consumer of energy, producer of goods, and holder of a vast supply of the world's dollars. Prior even to World War II, Japan had built up one of the world's mightiest war machines, had developed industrial complexes on the Home Islands and on occupied territory in

Korea and China, and had constructed two of the world's largest battleships, the world's second largest hydroelectric complex, the world's most advanced coal-to-oil conversion plant, and one of the world's largest integrated electrochemical complexes. The industrial development of Japan in the post-World War II and Korean Conflict periods is summarized in the following pages.

2.2.1 Historical Aspects

Japan's industrial reemergence essentially began during the Korean Conflict, when the United States initiated "special procurements" in Japan, for both geographic and economic reasons. The Allied Occupation's dictated Constitution forbade the Japanese to possess an armaments industry capable of producing the "weapons or means of war." This prohibition caused the generation of considerable subterfuges in the fabrication of equipment to support the UN Forces in Korea, such as vehicle "repair and overhaul" facilities to rehabilitate U.S. military equipment recovered from the Pacific Islands. These facilities were remarkably similar to U.S. military vehicle production lines and provided a strong base for the contemporary Japanese automobile industry.

Prior to the Treaty of San Francisco in 1952, the level of economic activity in Japan was so low, and the occupation and associated aid programs so dominating that the entire concept of "foreign trade" and domestic manufacture was remote. The 1950-1955 period was therefore critical to the future of Japan because, with American help particularly in the areas of technicological modernization, the foundations of a new industrial base — the base that is currently generating the energy forecasts prepared by the Ministry of International Trade and Industry (MITI) — were established. By 1955 Japan's GNP had reached the peak of her pre-war production. Japan's international focus was, however, almost solely U.S.-based, and her economy could best be described as internally oriented. During the period 1955-1970, Japan's energy demand essentially paralleled growth in GNP, although demand began to outstrip planned imports by 1970.[1] Shortfalls were made up by an aggressive import program, and, initially spurred by foreign orders, Japan's shipbuilding industry began to provide domestic suppliers with tankers up to 300,000 dwt, as well as smaller vessels, more suited for passage through the Straits of Malacca.

2.2.2 Recent Developments

The political and geopolitical implications of the impending "world energy crisis" upon Japan were first publically identified by the Japanese Government in the mid-1960s. The Ministry of International Trade and Industry was charged with the responsibility of establishing an industrial contingency plan through the year 2000, and a recommended course of activities through at least 1980. Several alternative contingencies were hypothesized, based primarily upon variations in the GNP. Fluctuations in international relations such as unilateral action by oil producing nations in raising their prices; closing of the Straits of Malacca or the Lombok Straits; or major new oil finds accessible to Japan were not given serious consideration in the basic contingency planning documents.

A special board was established by MITI, and a series of panels, each staffed by specialists in various energy areas, were convened. The board focused upon Japan's present energy requirements as a factor of GNP and projected energy requirements for the next two decades. The first report was published in 1967 and accurately forecast that Japan was headed into an energy crisis of significant proportions.

The forecast was immediately endorsed by fact, when the "projected" energy demand for 1970 was reached in 1968.[2]

MITI reacted to this situation by establishing a "Board of Investigation of Energy Requirements," which was charged with making realistic supply and demand assessments and setting the appropriate political courses of action for the government, and, through the government, for industry. On 2 May 1970, in the context of the MITI charter for the economic and industrial guidance for Japan, the "New Economic Social Development Plan" was promulgated, a series of guidelines which reflected strong reaction to the present and forecast energy situation. Another input to the plan is the proposed reorientation of the Japanese socio-economic situation by Prime Minister Tanaka, as presented in his controversial book Building a New Japan — A Plan for Remodeling the Japanese Archipelego.[3] In this work (written before he assumed the office) the Prime Minister proposed the dispersal of Japanese industry and commerce from the overcrowded Pacific and Inland Sea littoral to the relatively underpopulated and underdeveloped interior, to interior Shikoku, to the Japan Sea Coast, and to Hokkaido. This proposal has not received wide popular acceptance by the Japanese (who despite inducements have been reluctant to emigrate even to Hokkaido because of the — to them — harsh climate), and its implementation must be considered doubtful when projecting either Japan's energy requirements or its socio-economic situation in the next decade.

History records, therefore, that Japan did not suddenly burst upon the scene as an advanced technology, highly competitive superpower, but rather as a result of a rapid, but rational, evolutionary growth period that has now brought her to a position of strong economic influence on world industry and commerce.

Such growth is not without its price, however, and Japan, facing an incipient energy crisis, has recognized that unlimited growth and a soaring GNP extract both economic and social penalties. Throughout the past decade the GNP growth (itself excessive, > 11 percent) was exceeded by the energy demand growth, which approached 13 percent. Japan, dependent upon imports, recognized the serious nature of the problem and saw the necessity to institute steps to rectify the situation.

The die was already cast when much of Japan's industry and a large portion of her power generation capabilities were converted from coal to petroleum. For many years Japan's domestic coal supplies had been adequate to meet the needs of her electrical power industry. However the combination of increasing air pollution problems, and the construction of new massive, advanced-technology thermo-electric plants required that a large portion of imported oil be diverted to this sector. Japan continued to import metallurgical coal (domestic coal is deficient in the qualities required to support a contemporary basic steel indstury), but her dependence upon imported petroleum rapidly emerged as the single most critical factor in the energy crisis that lay ahead (see Table 2.1).

The petroleum dependency problem was compounded by the fact that there were three major demand sectors in which petroleum was an essential ingredient.

- Petroleum could be consumed in the thermoelectrical plants of Japan and thus contribute to the overall energy distribution, in a mix with hydroelectric and (eventually) nuclear power.

- Petroleum could be consumed immediately by the transportation sector of the economy and be distributed

Table 2.1. Overview of Japan's Oil Imports as of 1971 (4)

Country or Area	Date Oil Imports Began	Percent Strongest Year	Percentage of 1971 Imports	Remarks
Saudi Arabia	1959*	22.4 (1962)	12.35	Decline from prior years
Kuwait	1959*	38.4 (1960)	8.13	Steep decline
Neutral Zone	1959*	16.2 (1965)	8.43	Slight decline
Ras Khafji	1961	13.5 (1966)	7.58	Slight decline
Iran	1959*	43.7 (1969)	39.54	Largest source of oil
Iraq	1959*	14.3 (1959)	0.07	Strong decrease
Qatar	1959*	1.2 (1963)	0.02	Never high
Abu Dhabi	1962	9.1 (1971)	9.05	Strong increase recently
TOTAL MIDDLE EAST (Persian Gulf)		90.0 (1966)	85.17	Slight decrease
Sumatra	1959*	13.0 (1970)	11.08	Basically level
New Guinea (W. Irian)	1959*	0.5 (1959)	0.02	Never above 0.5%
Borneo	1959*	38.3 (1960)	1.44	Strong decline**
Kalimantan	1962	3.8 (1963)	0.12	New development
TOTAL S.E. ASIA		16.8 (1959)	12.66	See**
United States	1945		0.04	Data mixed with military rqmts. in 1945–1959 period — civil sector unknown
Venezuela	1959*	0.5 (1965)	0.20	Traditional supplier low level
Peru	1964	0.1 (1964)	negligible	Exploration only
Canada	None	None	None	Exploration only
Argentina	None	None	None	Exploration only
TOTAL N & S AMERICA		0.6 (1963/4/5)	0.24	Exploration primary mode; Panama Canal bottleneck.
Soviet Union	1959*	5.1 (1960)	0.19	Decline, new negotiations in progress
Rumania	1964	0.5 (1966/7)	negligible	
TOTAL EAST EUROPE		6.0 (1961)	0.19	
Cabinda	1969	Unknown	0.30	New developments to be expanded
Libya	Unknown	0.4 (1970)	0.59	LNG also important
Nigeria	Unknown	Unknown	0.30	Biafra conflict slowed development
Egypt	1968	0.7 (1970)	0.36	
TOTAL AFRICA ***		1.6 (1971)	1.55	

* Supplier prior to 1959, but data not included.

** Decline of trade with "British Borneo" and initiation of trade with "Malaysian Borneo," and similar problems in the relationships with Indonesia accounted for low trade and imports with these areas. Exploration currently actively pursued.

*** Although Japan desires to expand imports from Africa, sources are either in West Africa (Cabinda and Nigeria) or the Mediterranean Middle East (Libya and Egypt). Tankers that may transit the Panama Canal are limited to 106' beam and 900' loa (see Reference 14) which represents approximately 50,000 dwt. VLCCs would require voyages of from 16,000 nm to 21,000 nm via Malacca or Lombok from these sources.

between the fuel tanks of private cars, diesel locomotives, aircraft and coastwise shipping. (Petroleum also occupies a "halfway position" in the electrical power generation for Japan's extensive network of National and Private Railroads.)

- Finally, petroleum could be diverted from the energy cycle completely and be consumed by the petrochemical industry in its various forms ranging from naptha to textiles and plastics.

In similar fashion coal, particularly domestic coal, could be used either in the energy generation processes in thermoelectric plants, or directly in the plastics and textile industries in non-energy applications. Only hydro-electric power was a dedicated energy source — its only use was the generation of electricity, and it came from a completely domestic source. However, contemporary pump-storage power stations have emerged as consumers as well as producers of energy, a point that will be subsequently addressed.

Because of her dependence upon imported petroleum in her economy Japan took the following steps to assure supplies:

- Initiation of a tanker construction program of Very Large Crude Carriers (VLCC) in the ± 200,000 deadweight ton (dwt) range, and Ultra Large Crude Carriers (ULCC) in tonnages up to one million tons.

- Establishing control in production and transportation of oil, so as not to be a consumer at the mercy of the producing nations (primarily the Persian Gulf States). To this end, the Japanese Government financed the "Petroleum Development Corporation" with appropriate venture capital, and a charter for exploration outside the Middle East.* At the same time, joint ventures were

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* For example, a group of some thirty large Japanese companies with backing and blessing of the Petroleum Development Corporation formed a firm called the "North Slope Petroleum Company." The company has recently disbanded.

sponsored in the Middle East, primarily in Abu Dhabi. Exploration ventures spanned the promising in Indonesia, the potential in Southeast Asia, the speculative in southern Peru. Japanese firms contracted to supply the pipelines, and build the ports and storage facilities. Japan thus plans to establish control or strong influence in all elements of the wellhead to consumer cycle. The proposed pipeline across the Kra Isthmus in Thailand(5) is an example of such a venture. An example of a successful Japanese overseas oil development is the North Sumatra Oil Development Company. Agreements have been signed between Japanese firms and Indonesia covering cooperative offshore exploration and eventual production in southern Kalimantan and northern Sumatra. Japex-Indonesian Limited, for example, has already several drill ships and rigs operating in the area.(6)

2.3 Consumption Forecasts and Sources of Energy

Petroleum imports will continue to be important but will be supplemented by other energy sources. Most of Japan's oil comes from the Middle East; however, Japan intends to reduce her Persian Gulf petroleum imports from 85 percent in 1971 to 55 percent in 1985. Ongoing developments in Indonesia and particularly in South America seem to offer increasing promise for petroleum reserves which would enable Japan to meet these goals. Currently, the energy balance is as follows:

- Japan depends on imported sources for more than 85 percent of her energy requirements. In turn, 85 percent of imported petroleum comes from the Persian Gulf (1972).

- Domestic energy sources (less than 15 percent of the total) are concentrated in the production of electric power; these sources include all of the hydroelectricity (6 percent) and half of the domestic coal (3 percent). The electric power industry also calls upon 12 percent of the imported oil.

- The bulk of imported coal is of metallurgical grade and goes directly to the iron and steel industry.

- Nuclear power still accounts for a very small fraction of the energy supplies of Japan.

- Liquified Natural Gas although insignificant in the context of the total energy picture of 1971 is assuming a role of peak capacity buffer reserve in municipal gas systems, similar to the situation in the United States. Two new LNG tankers delivered in 1972 should increase the use of this fuel in subsequent years.

- Hydroelectric power has a similar role in the production of electricity. Pumped storage stations are either on line or are being built, and Japan beginning in 1971 has gone to a stated policy of using hydroelectric power primarily for peak period (August) reserve and supplemental energy. During non-peak periods, some hydroelectric installations become consumers rather than producers of energy as they activate their pumped storage systems.

2.3.1 Energy Demand Projections

Japan's future energy demand will be significantly affected by the pace of national economic growth as well as by the composition of her GNP, particularly as regards exports. The following variables are considered to be the most significant determinants of long-range energy demand: (a) economic activity (GNP), (b) population, and (c) ratio of fixed capital investment to private consumption expenditure. Other important factors to be considered are the price of energy and environmental factors.

Several official Japanese government groups as well as private research groups have made energy projections to 1985 for Japan. Their work has been a primary source of data in the preparation of this report. The principal reports were issued by the Ministry of International Trade and Industry,[2,7,8] the Institute of Energy Economics,[9,10] the Research Council of Mitsui and Co., Ltd.,[11] and the Overseas Electrical Industry Survey Institute, Inc.[12] The Government of Japan has also issued an official Economic and Social Development Plan to govern growth in Japan to 1975. The most probable range of energy demands forecast by these groups as well as the SAI high, low and base case energy demand projections used in this study are shown in Figure 2.1. Also shown as a limiting envelope is the energy demand that would be experienced by Japan if she were to maintain as an upper bound her 13 percent a year growth in energy achieved in the period 1965 to 1970, and as a lower bound the 3 percent growth of energy demand experienced in the economic slump from 1970 to 1972. The high and low bounds of the limiting envelope shown in Figure 2.1 do not represent probable outcomes but do represent limiting extremes. The growth rates in energy demand implicit in the high, low, and intermediate (SAI base case) energy projections to 1985 shown in Figure 2.1 are given in Table 2.2.

Table 2.2. Different Energy Demand Growth Rates

Case	Growth Rate (Average Annual Percent Gain)			
	1971-1975*	1975-1980	1980-1985	1971-1985
High — Industrial Expansion Emphasis	10.0	10.0	8.8	9.6
Intermediate — SAI Base Case	7.6	7.8	6.4	7.2
Low — Personal Consumption Emphasis	5.2	6.8	6.0	6.0

* Reflects 1971-1972 recession.

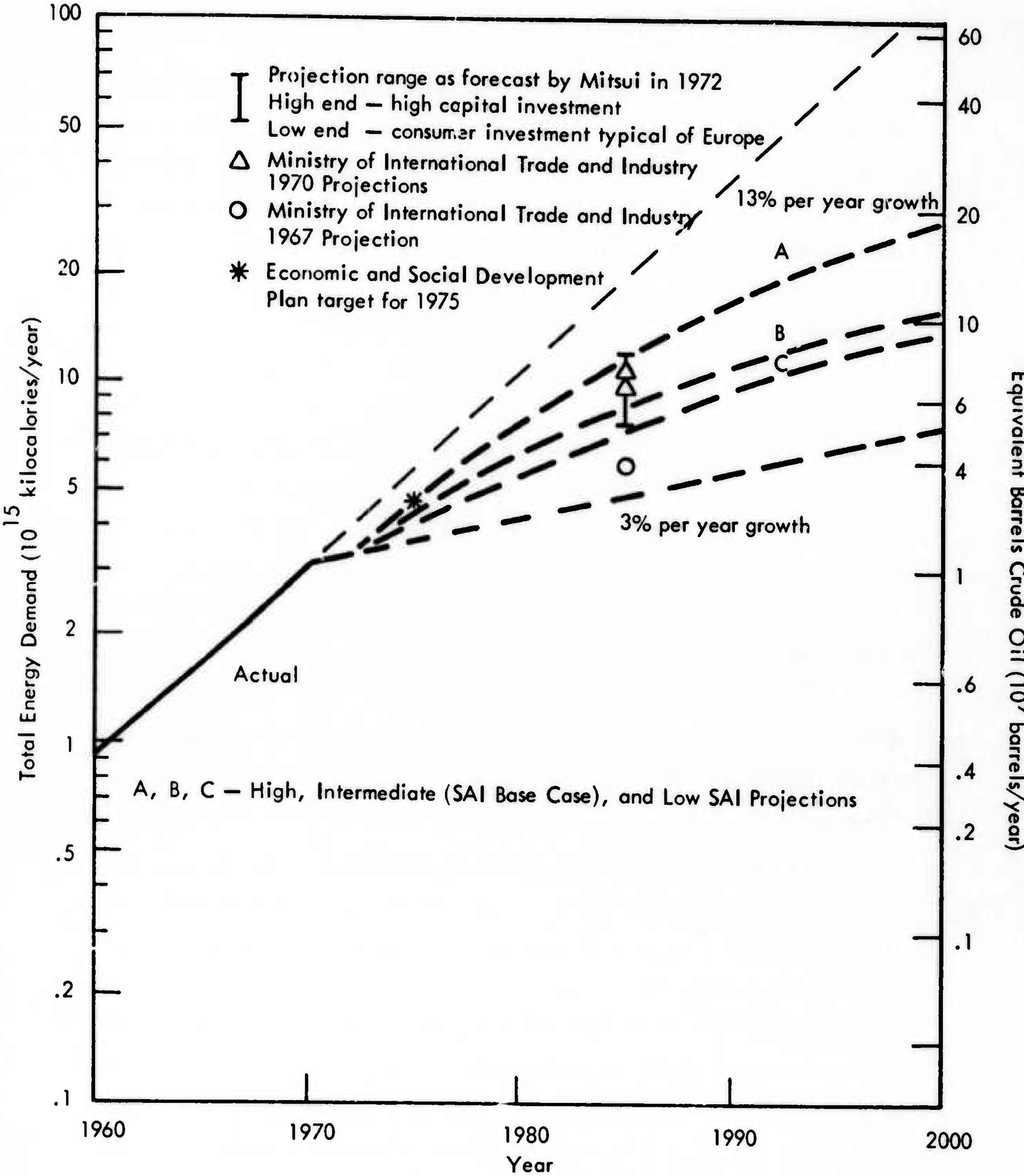


Figure 2.1. Projected Energy Demand (Supply) in Japan

The SAI base case energy demand projection was developed from available Japanese energy projections to represent what is considered the most probable future trend of economic growth and consumptive patterns. In order to understand the implications of the particular base case chosen, it is necessary to understand the composition of the current Japanese economy, in comparison with the economies of the U.S. or Western Europe. The present Japanese economy has a relatively high ratio of fixed capital formation to GNP and a relatively low ratio of private consumption to GNP. By continuing a high re-investment of capital in industry, Japan has been able to expand her GNP at a rate much higher than experienced in the United States. Such emphasis on capital expenditure has meant that industry in Japan requires a continuing greater share of total energy consumption than does industry in the United States. As a corollary, residential and commercial uses of energy are proportionately lower in Japan. In 1971, for example, about 54 percent of Japan's total energy supply went to industry and only 20 percent to residential and commercial uses. In the United States corresponding allocations were 37 percent and 33 percent, respectively.

In the near future the Economic and Social Development Plan adopted by the Japanese government to cover the period to 1975 calls for a continued emphasis on economic growth with a high ratio of fixed capital investment. However, the recession which started in 1971 has slowed the growth of the Japanese economy substantially and despite the emphasis being placed on economic growth the target energy demand of 4.7×10^{15} kilocalories/year for 1975, shown in Figure 2.1, does not appear probable. An increasing rate of growth is expected in the coming years as the effects of the recession lessen; however, it is logical to assume that the Japanese people will increasingly demand more consumer products, goods, and services. Such a trend will cause a shift in spending and in energy demand to the residential and commercial sector. A shift from capital investment to private consumption will also cause a reduction in the GNP growth rate in Japan. The effect on energy consumption is less straightforward for while high capital investment has tended to result in fast increases in GNP, it has also meant a smaller level of consumption. Thus, for example, high capital expenditure resulting in a rapid rise of GNP may not yield as rapid an increase in residential energy consumption as would a lower GNP growth rate coupled with higher private consumption. However, in terms of total energy consumption the economic studies of Japan do indicate a nearly one to one correlation between the ratio of capital expenditure to private consumption and the total energy growth rate.

The energy projections prepared by the various Japanese agencies previously listed, which were used by SAI in making the projections used in this report, were based on the following assumed GNP growth rates:

- High growth — 10.6% to 1975, 8.5% 1976 to 1985
- Intermediate growth — 10.6% to 1975, 8.5% from 1976 to 1980, 7% after 1981
- Low growth — 9% to 1975, 6% from 1976 to 1985

The economic slump of 1971-1972, which was not accounted for in the above figures, was treated as a delay factor in growth and all projections made by SAI have been corrected accordingly.

The overall energy demand was allocated to six consuming sectors, namely: industry, transportation, residential and commercial, agriculture and fishery, export, and non-energy. The demand of each individual sector was determined from the econometric fits and elasticity factors given by the various Japanese reports for each sector coupled with the assumed economic trends implicit in each of the different projections. The separate energy demands for each consumptive sector were then treated as percentages of the total demand to maintain consistency with the overall energy demand projections.

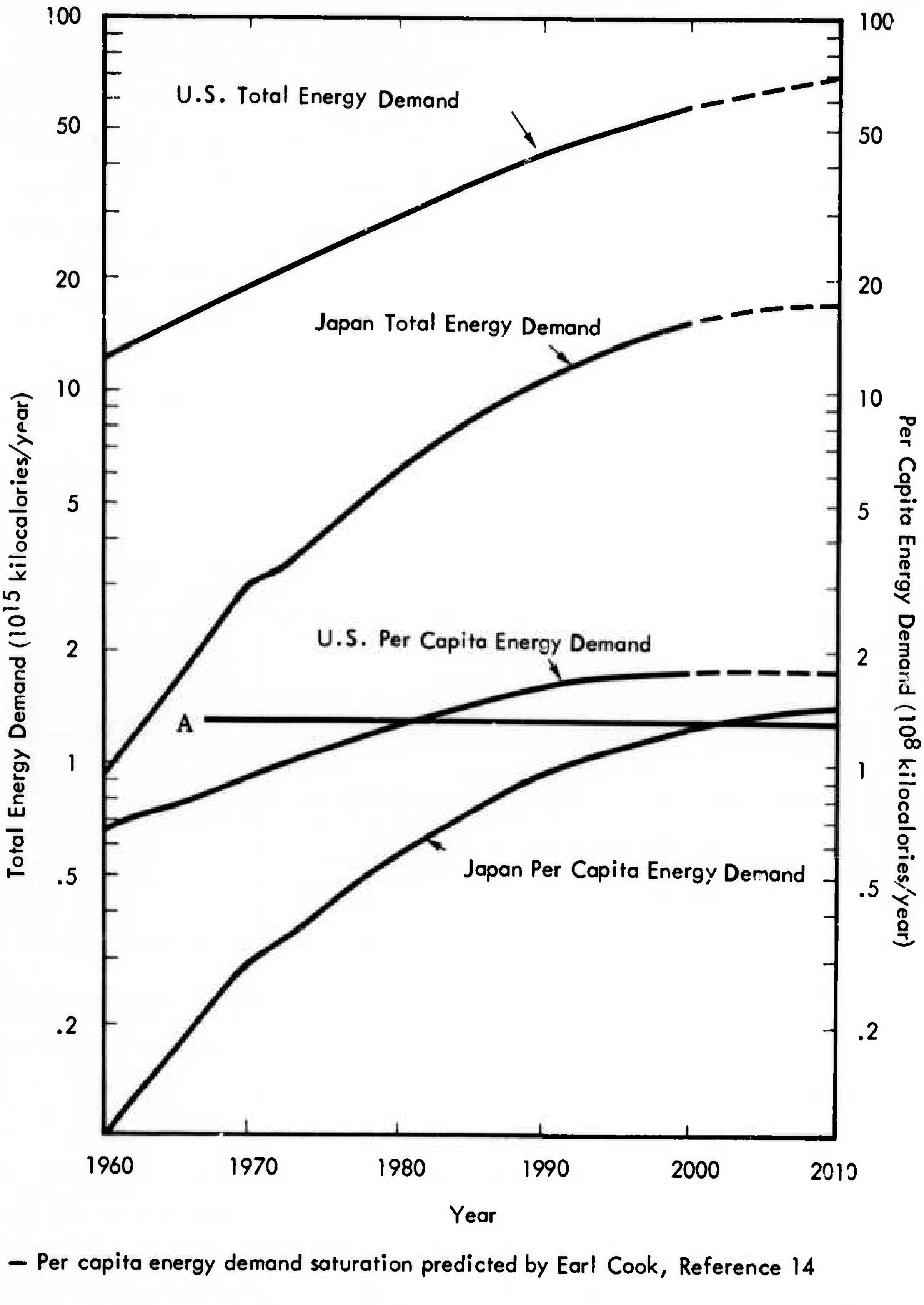
Energy supply sources were analyzed in terms of six basic energy sources, namely: nuclear, hydroelectric, coal, oil, gas, and firewood (including charcoal). Given the overall demands of each sector as determined above, each consumptive sector was studied to determine the present mix of fuels needed to meet the overall demand. Availability of fuels as determined from potential sources, developmental plans and required technological improvements were also considered and used to determine likely future fuel mixes. Thus, for instance, coal to be used for electrical generation is influenced by the number of existing thermal plants capable of using coal, planned additions for coal-fired plants as well as the production and reserves of domestic coal (coal for electric production in Japan is almost exclusively of domestic origin), environmental constraints, and the competing needs of the steel industry for imported coal. In general all supply sources except oil are very specific in their uses. Oil was treated as the universal supply source within each consuming sector and oil supplies were adjusted to meet overall demands and specific supply deficiencies. This assumed of course an orderly world marketplace for oil. The effect of imposing restrictions on available oil resources is trated in Section 4.

Beyond 1985 Japan's economy should shift from one of heavy reliance on industrial output to one more oriented to the consumer similar to the economies of the United States and Western Europe. In fact, the projections to 1985 indicate that Japan will be lagging the United States in terms of growth slowdown by about 10 to 20 years. This is logical since the United States has a higher per capita consumption of energy and would be expected to see a saturation effect causing a slowdown in demand for energy before Japan experiences a similar slowdown. Shown in Table 2.3 are the projected growth rates in energy demand in the United States[13] compared to the base case projections for energy demand increase in Japan.

Table 2.3. Comparison of Projected Growth in Energy Demand in Japan and the United States

Japan		United States	
Year	Base Case Average Annual Growth Rate (%)	Year	Average Annual Growth Rate (%)
1980-1985	6.4	1965-1970	5.0
1985-1990	5.2	1970-1975	4.5
1990-1995	4.0	1975-1980	4.0
1995-2000	3.0	1980-1985	4.0
		1985-1990	3.5

Another factor considered in the estimates of energy demand in Japan beyond 1985 is the ultimate energy consumption rate expected in industrialized society. As shown in Figure 2.2, the United States in 1970 had a total per capita energy demand of about 92 x 10^6 kilocalories/year whereas Japan's per capita energy demand was somewhat less than one-third of this amount. (Note that consumer per capita energy consumption in Japan was about one-sixth of that in the United States, whereas industrial per capita consumption was about one-half.) The



A — Per capita energy demand saturation predicted by Earl Cook, Reference 14

Figure 2.2. Projected U.S. and Japan Total and Per Capita Energy Requirements

National Petroleum Council's Committee Report on United States energy demand,[13] projected a total per capita energy demand of about 180×10^6 kilocalories/year in year 2000 (assuming a U.S. population of 320 million). Resources for the Future[14] has projected a leveling off in per capita consumption at a value of about 130×10^6 kilocalories/year. Japan's per capita consumption can be expected to level off somewhere in the above area, and as shown in Figure 2.2, the base case energy projection shows Japan's per capita consumption leveling off at about 143×10^8 kilocalories/year, assuming a stable population by year 2000 of 120 million in Japan. The limited land mass of Japan is apt to make environmental problems much more acute for Japan than for the United States and to limit to ultimate consumption in Japan below the ultimate United States level.

2.3.2 Energy Supply

Energy supplies for Japan has been analyzed in terms of six basic primary energy sources: nuclear, hydroelectric, coal, oil, gas, and firewood.* These have been further subdivided to show the fraction of domestic and imported sources. Shown in Figure 2.3 is the mix of the primary energy supplies for 5-year periods up to year 2000. Shown in Table 2.4 are the percentages of total supply both domestic and imported which make up the projected base case energy balance for Japan.

As can be seen in Figure 2.3 and Table 2.4, Japan is becoming increasingly reliant on oil for her energy needs, and the oil is

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* Firewood and its derivative, charcoal, fuel a substantial portion of rural Japan for cooking and space heating.

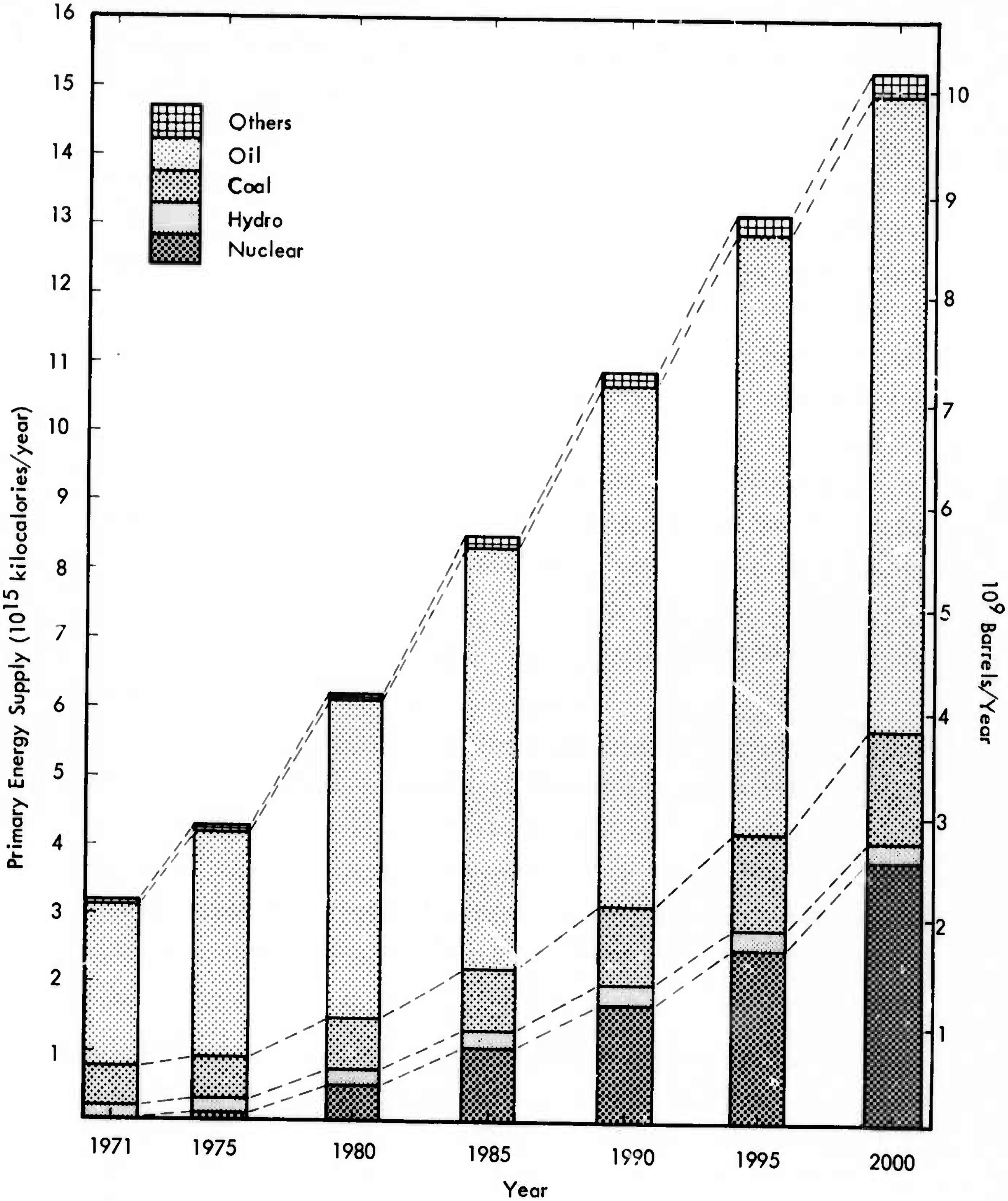

Figure 2.3. Energy Supply Mix in Japan for Base Case Energy Demand

Table 2.4. Projected Energy Balance for SAI Base Case for Japan

	Energy Demand (10^{15} kilocalories)				Percent of Total Energy			
	Actual	Projected			Actual	Projected		
Supply Source	1971	1980	1990	2000	1971	1980	1990	2000
Domestic Supply								
Coal	.218	.229	0.30	0.50	6.8	3.7	2.7	3.3
Hydropower	.212	.235	0.26	0.26	6.6	3.8	2.4	1.7
Gas	.027	.024	0.05	0.10	0.8	0.4	0.5	0.6
Oil	.008	.008	0.01	0.02	0.2	0.1	0.1	0.1
Wood	.014	.021	0.02	0.01	0.4	0.3	0.2	0.1
Total Domestic	.479	.517	0.64	0.89	14.8	8.3	5.9	5.8
Imported Supply								
Oil	2.348	4.633	7.53	9.21	73.0	74.1	69.1	60.2
Coal	.362	.500	0.85	1.10	11.2	8.0	7.8	7.2
Gas	.013	.080	0.13	0.25	0.4	1.3	1.2	1.6
Nuclear Fuel	.020	.520	1.75	3.85	0.6	8.3	16.0	25.2
Total Imported	2.743	5.733	10.26	14.41	85.2	91.7	94.1	94.2
Total Supply	3.223	6.25	10.90	15.30	100.0	100.0	100.0	100.0
NOTE: Energy for Electricity	.767	1.665	3.41	6.00	23.8	26.6	31.3	39.2

almost wholly imported. Shown in Figure 2.4 is the breakdown of energy supply for Japan in terms of domestic and imported sources. As can be seen Japan will become increasingly dependent upon imported sources for her energy needs.

Electricity as a fraction of total energy supply will increase slowly from about 24 percent in 1971 to 29 percent by 1985. In contrast, electricity as a fraction of total United States energy supply will increase from about 25 percent in 1970 to 35 percent in 1985. However, beyond 1985 as Japan's economy shifts to the consumer segment, electricity as a fraction of total energy will increase to about 39 percent by year 2000. Nuclear energy as shown in Table 2.4 will play the major part in the increase in electrical power beyond 1985. By year 2000 essentially all of the base load power generated in Japan will be nuclear and essentially all new generating capacity installed will be nuclear.

As Japan's requirements for Persian Gulf petroleum decrease, tanker traffic from these areas will tend to slacken, but in the relative, not absolute context. Based upon data provisionally developed in Reference 5 and the base case projections above, Japan required 172 million dwt of tankerage to meet her 1971 imports of crude oil from the Persian Gulf, will require 307 million dwt of tankers on the same routes in 1980, and only by 1985 will the requirements for tankers on the Persian Gulf slacken to 283 million dwt, as additional sources are opened worldwide (see Section 5).

Domestic supplies of fossil fuels (coal, oil and gas) are projected to show only a slight increase between now and 1985. Beyond 1985 domestic coal supplies are expected to once again increase as Japan develops better technology for mining thin seams of coal.

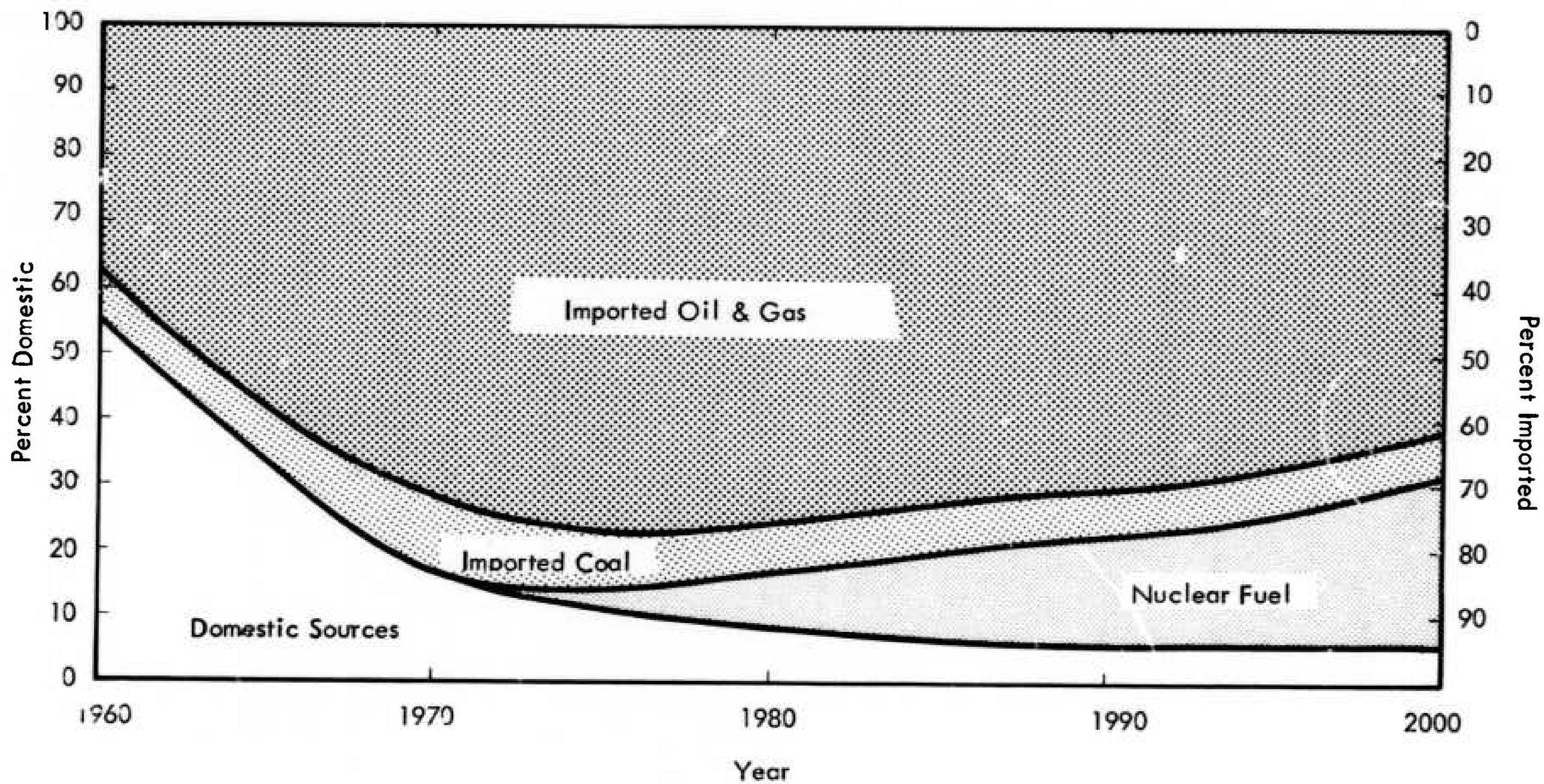

Figure 2.4. Distribution Apportionment of Domestic and Imported Energy Sources for Japan

Domestic coal is expected to total somewhat more than double present production rates by year 2000. Likewise domestic oil and gas supplies are expected to increase by year 2000 to somewhat more than twice present production rates accounting for some expected finds in continental shelf oil fields. However, domestic supplies will remain a very small fraction of total needs and increases in domestic supplies will not be sufficient to significantly affect imported needs.

Imports of liquified natural gas (LNG) are expected to increase by nearly an order of magnitude between now and 1985, and show a slower increase beyond 1985. However, LNG is presently a very small fraction of total energy needs (about 0.4 percent) and even with its rapid increase will amount to only about 1.2 percent of total energy needs in 1985. LNG is quite expensive and is really suited only for special needs so that no increase beyond a few percent of total energy needs is forecast. Thus, while Japan may be expected to greatly increase her LNG tanker fleet, the size of LNG imports will still not significantly affect the amount of crude oil imports needed or the size of the oil tanker fleet needed.

The choice of the base case energy demand projection and the discussion of the ranges of Japanese energy demand growth in Section 3 are based to a large extent on projections developed by Mitsui Corporation.[11] The econometric fits and economic analyses which formed in turn the basis of Mitsui's projections were not available to us; however, our projections are consistent with the hypothesis that a high capital investment growth rate is tied to industrial growth for export products (expansionary trade policy) leading to the highest energy growth rate — as opposed to industrial growth for internal consumer products (consumer welfare policy) requiring lower capital investment and leading to the lowest energy growth rate.

Section 3

RANGES OF ENERGY DEMAND

In addition to the primary energy supply case described in detail in the previous sections, alternative supply-demand balances have been made on the basis of different demand assumptions. The different demand assumptions are based in turn on different assumptions concerning economic, political and social conditions. The number of possible demand variations is extremely large, but the "high" and "low" energy demand cases were selected to bracket the most likely energy demand case described in the previous section. The projections of total Japanese energy demand for the high and low cases as well as the intermediate base case are shown in Table 3.1. Breakdowns of these ranges, by major consuming sector, are given in Table 3.2.

Table 3.1. Projections of Total Japanese Energy Demand for three Different Sets of Assumptions

Case	Energy Growth Rate (% per year)			Energy Demand (10^{15} kilocalories/year)	
	1971-1985	1985-2000	1971-2000	1985	2000
High	9.6	6.0	7.6	11.6	27.7
Intermediate (base)	7.2	4.0	5.5	8.5	15.3
Low	6.0	4.3	5.1	7.3	13.8

Table 3.2. Variant Projections of Japanese Energy Demand* by Major Consuming Sector

Sector	Demand Amount (10^{15} kilocalories/year)						
	1971	1985			2000		
	Actual	Low	Intermediate	High	Low	Intermediate	High
Industrial	1.68	3.36	4.07	7.23	5.09	5.95	16.95
Residential, Commercial	0.62	1.83	2.00	1.47	4.36	4.68	3.71
Transportation	0.39	1.12	1.29	1.48	2.25	2.48	3.77
Resources	0.07	0.12	0.14	0.14	0.22	0.20	0.28
Non-Energy	0.33	0.74	0.88	1.07	1.73	1.84	2.74
Export	0.13	0.12	0.12	0.21	0.15	0.15	0.25
TOTAL	3.22	7.3	8.5	11.6	13.8	15.3	27.7

Sector	Growth Rates (Average Annual Percent Change)						
	1960-1970	1971-1985			1985-2000		
	Actual	Low	Intermediate	High	Low	Intermediate	High
Industrial	11.9	5.1	6.5	11.0	2.8	2.5	5.8
Residential, Commercial	13.2	8.0	8.7	6.4	5.9	5.8	6.3
Transportation	11.3	7.8	8.9	10.0	4.7	4.4	6.6
Resources	12.1	4.9	5.1	5.[illegible]	4.1	2.4	4.7
Non-Energy	26.4	5.9	7.2	8.7	5.8	5.0	6.6
Export	12.6	0.0	0.0	3.[illegible]	1.5	1.5	1.1
GROWTH RATE OF TOTAL DEMAND	12.9	6.0	7.2	9.6	4.3	4.0	6.0

* As in all cases throughout this report all losses, stockpiling, etc. between supply and demand are appropriately assigned to consuming sector so that supply = demand.

It is important to note that the potential variability in the future growth of Japan on the basis of historical trends is quite large. First, Japan's entire economy and political institutions were essentially reconstructed after World War II, so that long-term growth data do not exist for the present Japanese economy. Second, in the process of "catching up" with other more industrialized nations such as the U.S., Japan has been able to achieve very high growth rates. Thus, while the U.S. has shown a relatively constant growth rate in energy demand of around 4 percent for many years, the energy growth rate in Japan was about 7 percent from 1953 to 1959 and went to 13 percent for the period 1960-1970. If, as has been argued by some,[15] the high growth rates achieved between 1960-1970 are due to basic characteristics of the Japanese economy, which are not apt to change, then future growth rates of 13 percent through this century may be achieved. Such a growth rate would mean that by year 2000 the total energy consumption in Japan would be on the order of 1.2×10^{17} kilocalories/year which is six times the total present U.S. energy consumption and would represent in year 2000 about 10 times present U.S. per capita energy consumption. In terms of projected growth rates in the U.S. and Europe, if Japan were to maintain a 13 percent per year growth in energy demand then by year 2000 Japan's energy needs would be greater than those of the U.S. and all of Western Europe combined. Since oil will of necessity satisfy the majority of Japan's energy needs through year 2000 unless a major technological breakthrough occurs before then, the implications of such a growth rate on oil supplies for Japan and for the U.S. would be staggering.

Moreover, a per capita energy consumption 10 times greater than that in the U.S. at present does not seem reasonable. The Japanese economy has achieved a remarkable growth record, and growth rates which are higher than those in the U.S. can reasonably be expected to be achieved until at least 1985. However, at least a part of the very fast growth which Japan has achieved is probably due to a "catch up" effect which will die out as Japan reaches a par with other more developed nations such as the U.S. There is also the expectation that energy demand must begin to experience saturation effects at some point. For instance, with a 13 percent growth rate, before year 2010 Japan's energy consumption would be greater than the total solar input to the entire land mass of Japan. The environmental problems associated with the production and dissipation of such an enormous amount of energy suggests that limits on Japan's use of energy will be required well below such a value.

Since 1970 Japan's economy has experienced an economic slump and energy usage only increased at a rate of about 3 percent in 1971 and 1972. While this economic slump is probably atypical of the future, it does suggest that the Japanese economy can also have problems and reattaining an energy growth rate of 13 percent does not appear at all likely. In particular, the present problems Japan is encountering in increasing her exports without upsetting worldwide balance-of-payments, coupled with upward revisions of her currency suggest that as Japan represents a bigger proportion of world trade, her opportunities for maintaining a much faster rate of growth than other countries will greatly reduce. The official policy of Japan is still to push for rapid economic growth, but recent Japanese publications have reduced the projected energy demands, and tanker requirements for 1975 have recently been reduced.

The evidence thus suggests that a forward projection of the 13 percent growth rate achieved by Japan in the period 1960-1970 is too extreme. Nevertheless, the Japanese economy has certainly demonstrated an ability to achieve very rapid growth rates, so that high rates of growth must be considered a possibility. In contrast, growth projections for the United States can more reasonably be confined to a narrow range since the extremes in energy growth experienced in Japan have not been experienced in the more mature U.S. economy. Thus, while the National Petroleum Council's [13] forecast of high and low ranges cover a range of growth of only 4.4 to 3.4 percent a year for 1971 to 1985, the Japanese forecasts in this report cover a range of 6.0 to 9.6 percent a year growth in energy. As a further consequence, many sensitivity analyses on factors which might reasonably affect energy growth by a few tenths of a percent may be of interest in a U.S. energy study, but are not important for a Japanese projection given the wide deviation in basic growth rates of the three cases we are already analyzing. For instance, shown in Figures 3.1 and 3.2 are the likely fuel mixes for the three different energy projection cases for years 1985 and 2000, respectively. As can be seen from the graphs, even if nuclear power development were to be completely stopped, the effect on the critical energy supply source, oil, by year 2000 would be much less than the potential change of oil supply implicit in the three different growth projections. This is obviously a simplified view of things. It is apparent that the various supply and demand sectors are interrelated in such a way that the high case energy demand is inconsistent with a cessation of nuclear power development. Thus, detailed sensitivity analyses of the effect of nuclear power costs are not apt to be highly significant. Likewise, detailed studies of population trends have not been made since any reasonable deviations from the 120 million population forecast for Japan by year 2000 are apt to affect the energy growth rate by only a few tenths of a percent. It is important, however, to understand the significant factors implicit in each of the three projection cases and how these factors are apt to impact on energy supply. Each of the three different cases are, therefore, described separately below.

3.1 Low Case

The basic assumption in the low case is that personal consumption in Japan rapidly jumps to levels characteristic of the United States and Western Europe, with a correspondingly fast drop in the rate of capital investment. Specifically, the growth rate of capital investment drops to about 3 percent as is typical of the U.S. at present.

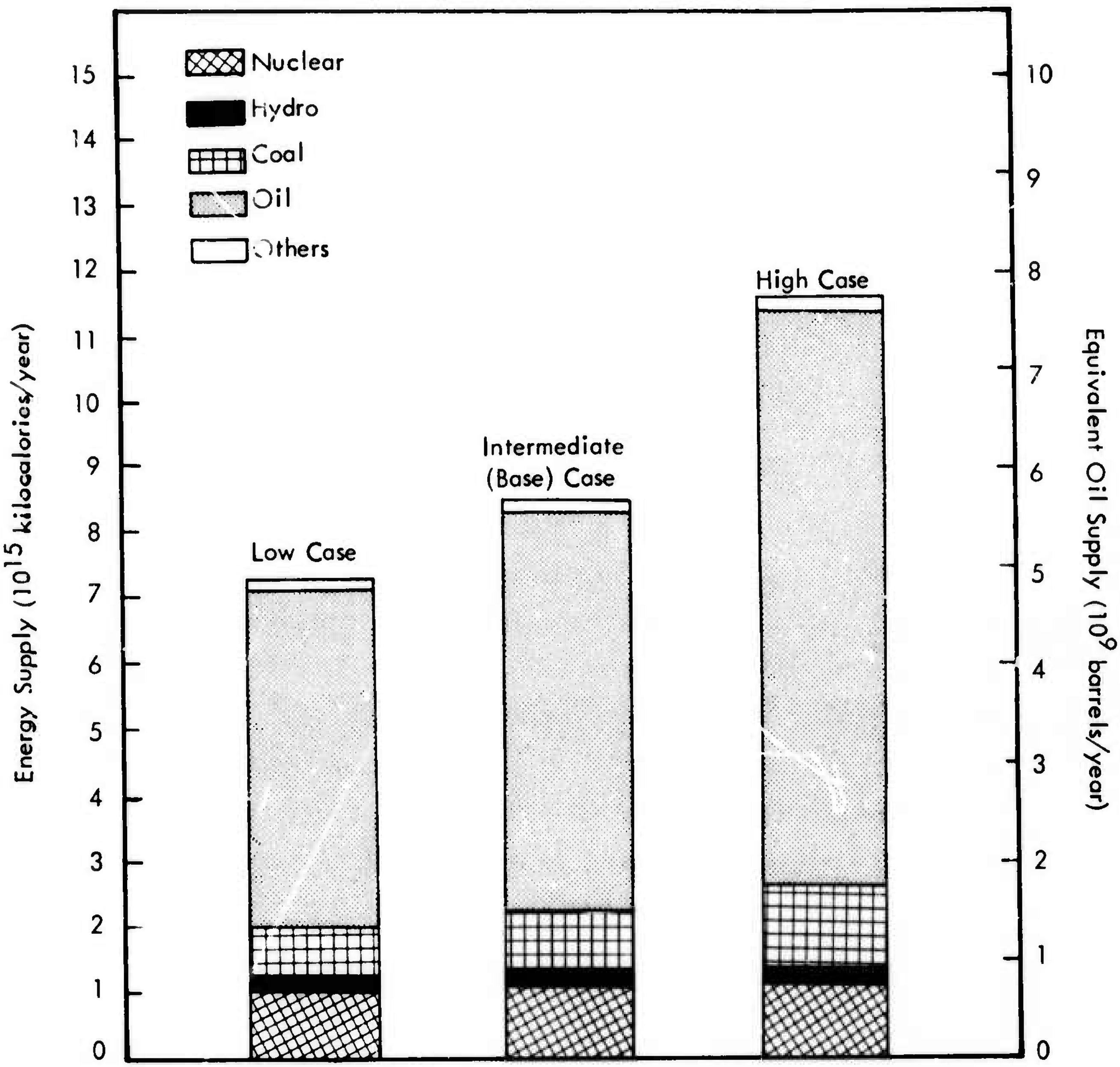

Figure 3.1. Energy Supply Mix for 1985, Three Cases

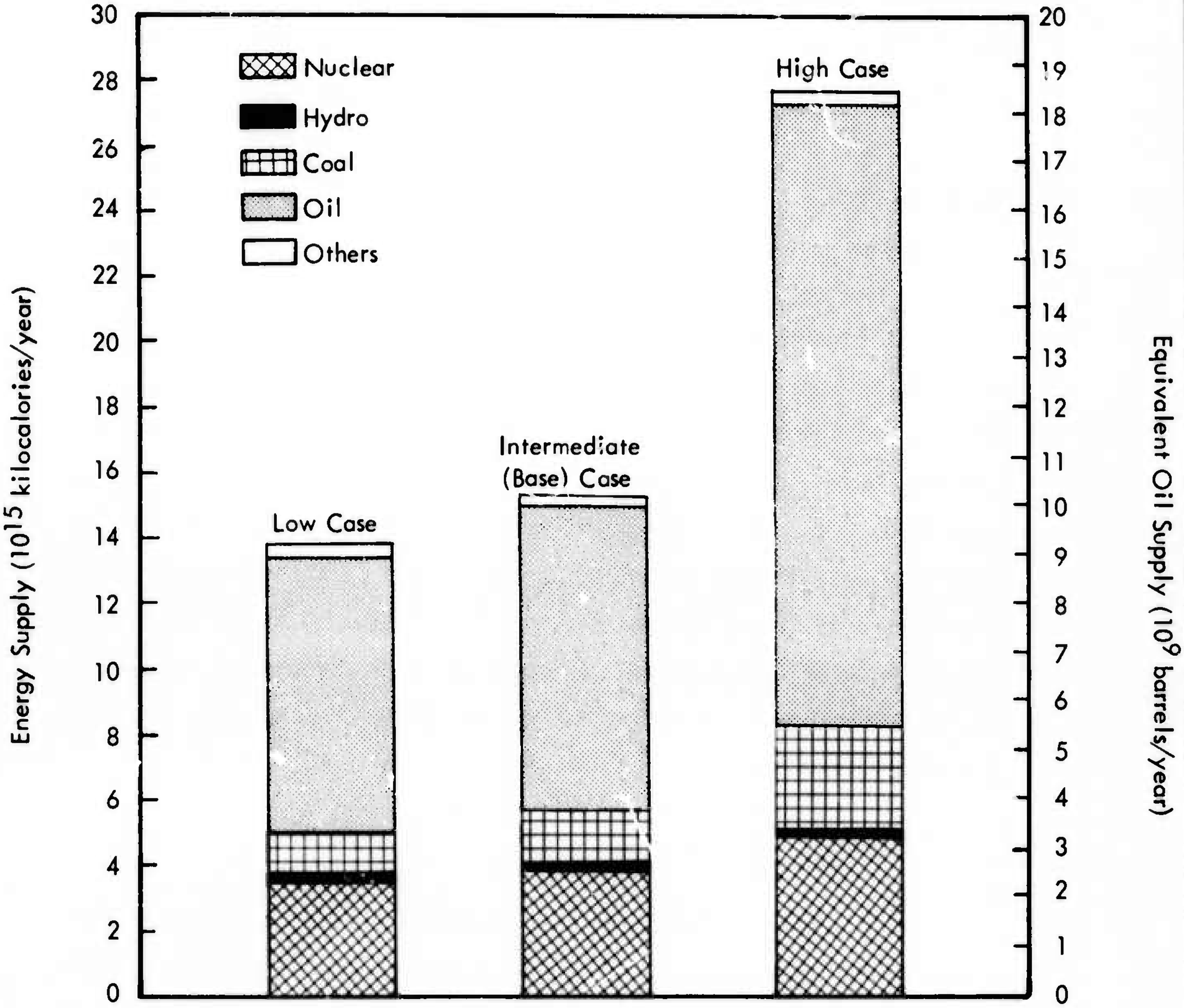

Figure 3.2. Energy Supply Mix for 2000, Three Cases

As a consequence of this shift in consumption and investment trends, the GNP growth rate in Japan declines and industrial growth rate in particular declines to less than the growth rate in GNP. At the same time personal consumption increases rapidly with residential and commercial consumption of energy growing to 25 percent of total energy consumption in 1985 from less than 20 percent in 1971.

The increase in personal consumption forecast in the low case further results in an increase in electrical demand, particularly in the residential and commercial sectors. The result is that electrical consumption increases from about 24 percent in 1971 to 33 percent in 1985 and 40 percent in 2000. In terms of percentage the low energy case is the high electricity case. Nuclear power, however, is forecast to undergo the slowest development in the low energy case. This is a result of the assumption that success in changing the government emphasis on continued economic growth is likely to be coupled with some success of environmental groups (and the fishing industry) to slow the development of nuclear power. No drastic slowdown in nuclear power, however, is forecast as environmental pressures for cleaner air should increase competing fuel costs sufficiently to make nuclear power economical.

3.2 Intermediate (Base) Case

The intermediate case differs from the low case in that the assumed shift to personal consumption occurs at a slower rate and the slowdown in economic growth is also correspondingly slower. Note further that the base case analyzed by SAI assumes an approach to an energy saturation level near the year 2000 which causes the intermediate case growth to taper off to a slower growth rate than the low case. At some time after 2000 the low case will also approach the saturation level and energy growth will taper off. However, the low case is not assumed to be affected by saturation effects before year 2000. The implications of the intermediate energy demand case in terms of energy supply have already been discussed in Section 2 and will not be repeated here.

3.3 High Case

The high case assumes that the emphasis on industrial growth is maintained with a resultant continued small percentage of personal consumption. The high case results in a continued rapid increase in industrial sectors, with industrial energy demands (including petrochemical energy demands contained in "non-energy") continuing to account for more than 60 percent of total energy consumption in Japan. The high case further assumes that with the continued emphasis on economic growth that energy saturation effects will not be felt until much higher levels of energy consumption are reached. Thus, no saturation effects are included in the high case.

In order for Japan to meet the energy projections made in the high case, she would need to continue to have a very high degree of success in all areas of industrial growth. Thus, the high case assumes that environmental restraints will not greatly slow the rate of industrial growth or raise energy prices. Nuclear power is also forecast to undergo the fastest development in the high case. However, industrial energy demands for oil and coal will be such that even with rapid growth in the nuclear industry, nuclear power will constitute less than 20 percent of the total energy supply by year 2000 (in the base case, for comparison, nuclear power development will be slower but nuclear power will amount to 25 percent of total power in year 2000). High industrial demand for energy coupled with a low percentage of private consumption will also mean that electrical energy will account for only about 30 percent of total energy in year 2000 as compared with 35 and 40 percent for the intermediate and low cases, respectively.

The implications of the high growth case are quite significant in terms of coal and oil supplies. In the high case, coal needs for industry will increase sufficiently to require total coal supplies to increase by about 120 percent by 1985 and by year 2000 to be 5.5 times present supplies. This demand could significantly impact the U.S. coal industry which could be expected to be a major supplier of coal. The implications in terms of oil supplies of the high growth case are even more significant. As can be seen from Figure 3.3, the rate of growth of oil supplies needed by Japan continues to increase until about 1995, and the absolute demand for new oil supplies per year peaks at a value more than twice that for the intermediate case. In the high case Japan would have to add 8,000,000 dwt or more of tankers each year starting in 1980 and continuing through year 2000. By 1985 Japan's imported oil supplies would be equal to 16.5 million barrels/day, and by 2000 Japan would need imported oil supplies of 37 million barrels/day. These demand figures would significantly affect the ability of the U.S. to secure projected oil import demands.

The high demand case might appear to be the most likely case if strict time-trend projections of 1960 to 1970 growth data are used. The high demand case also agrees most closely with the energy requirements implicit in the Japanese remodeling plan described by Japan's Prime Minister Tanaka.[3] However, judging from the events of the last few years in Japan and the behavior of more mature economies such as the U.S., it appears that some of Japan's fast spurt in growth is due to "catch up" effects which are rapidly disappearing. Further, the relocation of people and industry, an integral part of Tanaka's plan,

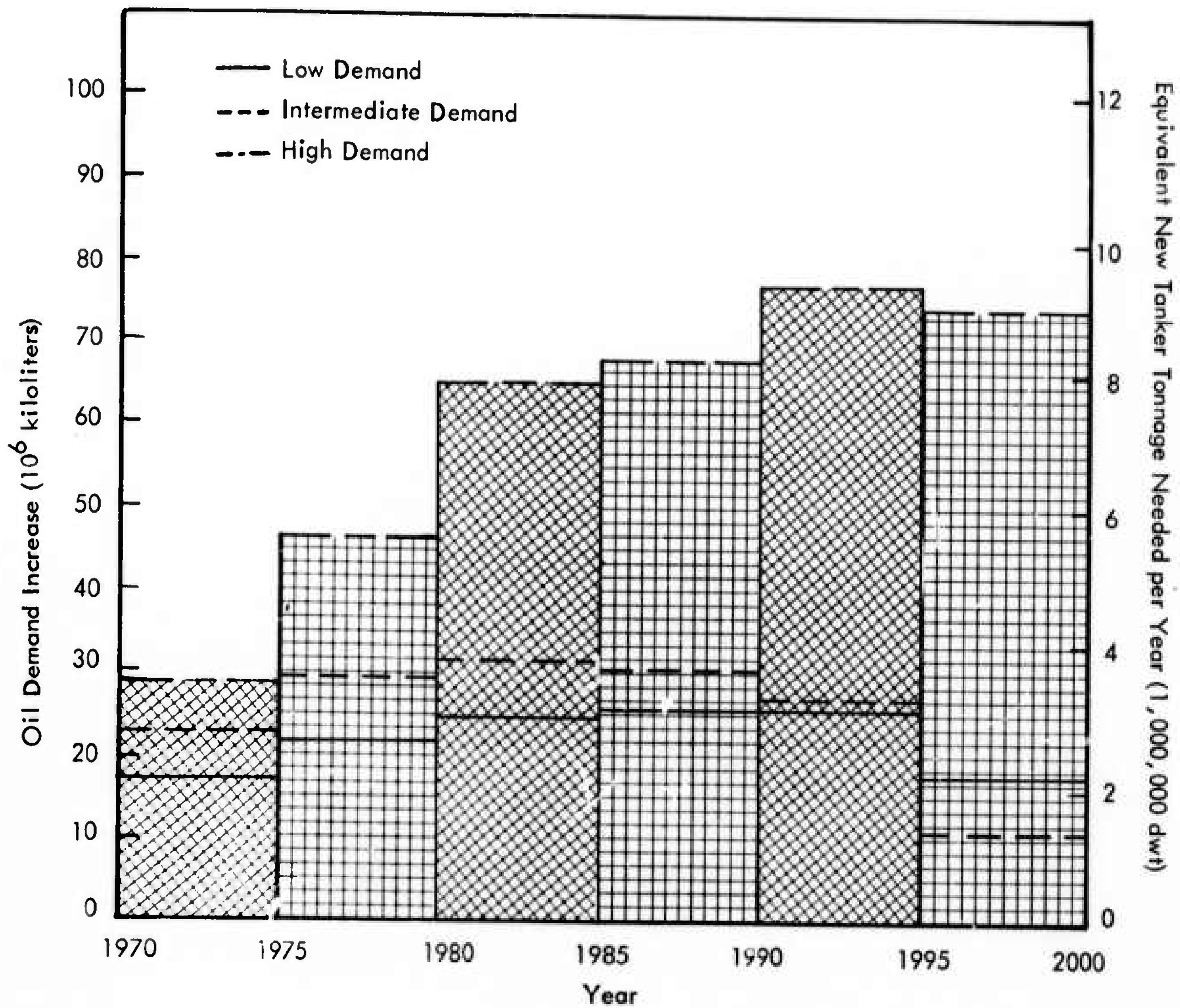

Figure 3.3. Annual Average Increase in Oil Supplies

is not occurring as outlined in Tanaka's plan. It seems more likely, therefore, that Japan's growth rates will taper off to those more characteristic of the U.S. and Western European nations and for this reason SAI considers the high growth case, while possible, the least likely of the three growth cases.

Projections of energy demands by fuel for the three different cases are given in Tables 3.3, 3.4, and 3.5. Detailed energy balances for 5-year intervals can be found in Section 4.

Table 3.3. Projection of Required Energy Supplies (Low Case)

Supply Source	Energy Demand (10^{15} kilocalories)				Percent of Total Energy			
	Actual	Projected			Actual	Projected		
	1971	1980	1990	2000	1971	1980	1990	2000
Domestic Supply								
Coal	0.218	0.22	0.22	0.30	6.8	4.0	2.4	2.2
Hydropower	0.212	0.23	0.26	0.26	6.6	4.2	2.8	1.9
Gas	0.027	0.02	0.05	0.10	0.8	0.4	0.5	0.7
Oil	0.008	0.01	0.01	0.02	0.2	0.2	0.1	0.1
Wood	0.014	0.02	0.02	0.01	0.4	0.4	0.2	0.1
TOTAL DOMESTIC	0.479	0.50	0.56	0.69	14.8	9.1	6.0	5.0
Imported Supply								
Oil	2.348	4.01	6.35	8.41	73.0	73.0	68.3	61.0
Coal	0.362	0.44	0.66	0.95	11.2	8.0	7.1	6.9
Gas	0.013	0.08	0.13	0.24	0.4	1.5	1.4	1.8
Nuclear Fuel	0.020	0.47	1.60	3.50	0.6	8.5	17.2	25.4
TOTAL IMPORTED	2.743	5.00	8.74	13.11	85.2	90.9	94.0	95.0
TOTAL SUPPLY	3.223	5.50	9.30	13.80	100.0	100.0	100.0	100.0
Note: Energy for Electricity	0.767	1.65	3.33	5.57	23.8	30.0	35.8	40.4

Table 3.4. Projection of Required Energy Supplies (Base Case)

Supply Source	Energy Demand (10^{15} kilocalories)				Percent of Total Energy			
	Actual	Projected			Actual	Projected		
	1971	1980	1990	2000	1971	1980	1990	2000
Domestic Supply								
Coal	0.218	0.229	0.30	0.50	6.8	3.7	2.7	3.3
Hydropower	0.212	0.235	0.26	0.26	6.6	3.8	2.4	1.7
Gas	0.027	0.024	0.05	0.10	0.8	0.4	0.5	0.6
Oil	0.008	0.008	0.01	0.02	0.2	0.1	0.1	0.1
Wood	0.014	0.021	0.02	0.01	0.4	0.3	0.2	0.1
TOTAL DOMESTIC	0.479	0.517	0.64	0.89	14.8	8.3	5.9	5.8
Imported Supply								
Oil	2.348	4.633	7.53	9.21	73.0	74.1	69.1	60.2
Coal	0.362	0.500	0.85	1.10	11.2	8.0	7.8	7.2
Gas	0.013	0.080	0.13	0.25	0.4	1.3	1.2	1.6
Nuclear Fuel	0.020	0.520	1.75	3.85	0.6	8.3	16.0	25.2
TOTAL IMPORTED	2.743	5.733	10.26	14.41	85.2	91.7	94.1	94.2
TOTAL SUPPLY	3.223	6.25	10.90	15.30	100.0	100.0	100.0	100.0
NOTE: Energy for Electricity	0.767	1.665	3.41	6.00	23.8	26.6	31.3	39.2

Table 3.5. Projection of Required Energy Supplies (High Case)

Supply Source	Energy Demand (10^{15} kilocalories)				Percent of Total Energy			
	Actual	Projected			Actual	Projected		
	1971	1980	1990	2000	1971	1980	1990	2000
Domestic Supply								
Coal	0.218	0.23	0.40	0.50	6.8	3.0	2.5	1.8
Hydropower	0.212	0.24	0.28	0.28	6.6	3.2	1.7	1.0
Gas	0.027	0.02	0.05	0.10	0.8	0.3	0.3	0.4
Oil	0.008	0.01	0.02	0.03	0.2	0.1	0.1	0.1
Wood	0.014	0.02	0.02	0.02	0.4	0.3	0.1	0.1
TOTAL DOMESTIC	0.479	0.52	0.77	0.93	14.8	6.8	4.7	3.4
Imported Supply								
Oil	2.348	5.71	11.92	19.07	73.0	75.1	73.5	68.7
Coal	0.362	0.75	1.35	2.60	11.2	9.9	8.3	9.4
Gas	0.013	0.09	0.16	0.30	0.4	1.2	1.0	1.1
Nuclear Fuel	0.020	0.53	2.00	4.80	0.6	7.0	12.4	17.3
TOTAL IMPORTED	2.743	7.08	15.43	26.77	85.2	93.2	95.3	96.6
TOTAL SUPPLY	3.223	7.60	16.20	27.70	100.0	100.0	100.0	100.0
NOTE: Energy for Electricity	0.767	1.90	4.37	8.31	23.8	25.0	27.0	30.0

Section 4

ENERGY BALANCES

4.1 Energy Balance Assumptions

This section contains detailed energy balances of fuel supplies and consumption demand and a brief examination of supply sensitivity to increased industrial demand and consumption sensitivity to reduced oil supplies. All energy projections have been made on the basis of demand, but demand projections have been translated to supply requirements in the energy balances. Any losses in energy between the supply side and the demand side have been appropriately prorated among the demands. Thus, a complete balance can be maintained without changing any important features on the supply or demand side. Similarly, energy for electricity conversion has been assigned to the ultimate user of the electricity. However, in order to preserve the information on energy flow to electricity, the energy balances will show separately energy flow to electricity. Actual electrical output, given the energy inputs to electricity shown in the balances, can be found by multiplying the inputs by the appropriate conversion efficiency factors which are discussed below.

Electrical power in all the balances shown has been taken to mean electrical power generated by the electric utilities of Japan. Industrial users of electricity who generate their own electricity for their own use (captive electrical capacity) have not been included in the electrical figures. Such captive supplies of electricity are direct users of fossil fuels, and fuel use is directly assigned to the industry rather than indicating the intermediary electrical generation.

Overall efficiency of conversion of energy to electricity in Japan is expected to remain about fixed through 1985 at a value of 37 percent. Fossil plant efficiencies, which are presently slightly less than 38 percent, will increase slightly between now and 1985, but this increase in efficiency will be offset by addition of nuclear plants which have lower conversion efficiency (about 32-34 percent). After 1985, overall electrical generation efficiency will increase slightly as higher efficiency-type nuclear plants are built and some combined-cycle fossil plants are built. However, Japan's present efficiency is already high (37 percent in comparison to 32 percent in the United States) and is not expected to increase beyond 40 percent.

4.2 Energy Balance Details

Given in Figures 4.1 to 4.7 are the detailed base case energy balances for Japan for the period 1971 to 2000. The balances show fuel inputs classified among coal, oil, gas, hydroelectric, nuclear, and wood, and also show the breakdown between domestic and imported energy sources. The balances allocate demand into six sectors, namely: industry, transportation, residential and commercial, agriculture and fisheries, export, and non-energy. Energy exports consist primarily of petroleum shipped to captive industries in Korea and Taiwan. Jet fuel purchased by foreign carriers is also included. Non-energy consists primarily of petroleum used in the petro-chemical industry. Also shown are the energy inputs into electrical generation. The energy input of each fuel individually to the consuming sectors was assigned using a simplified input/output model developed during the course of the study.

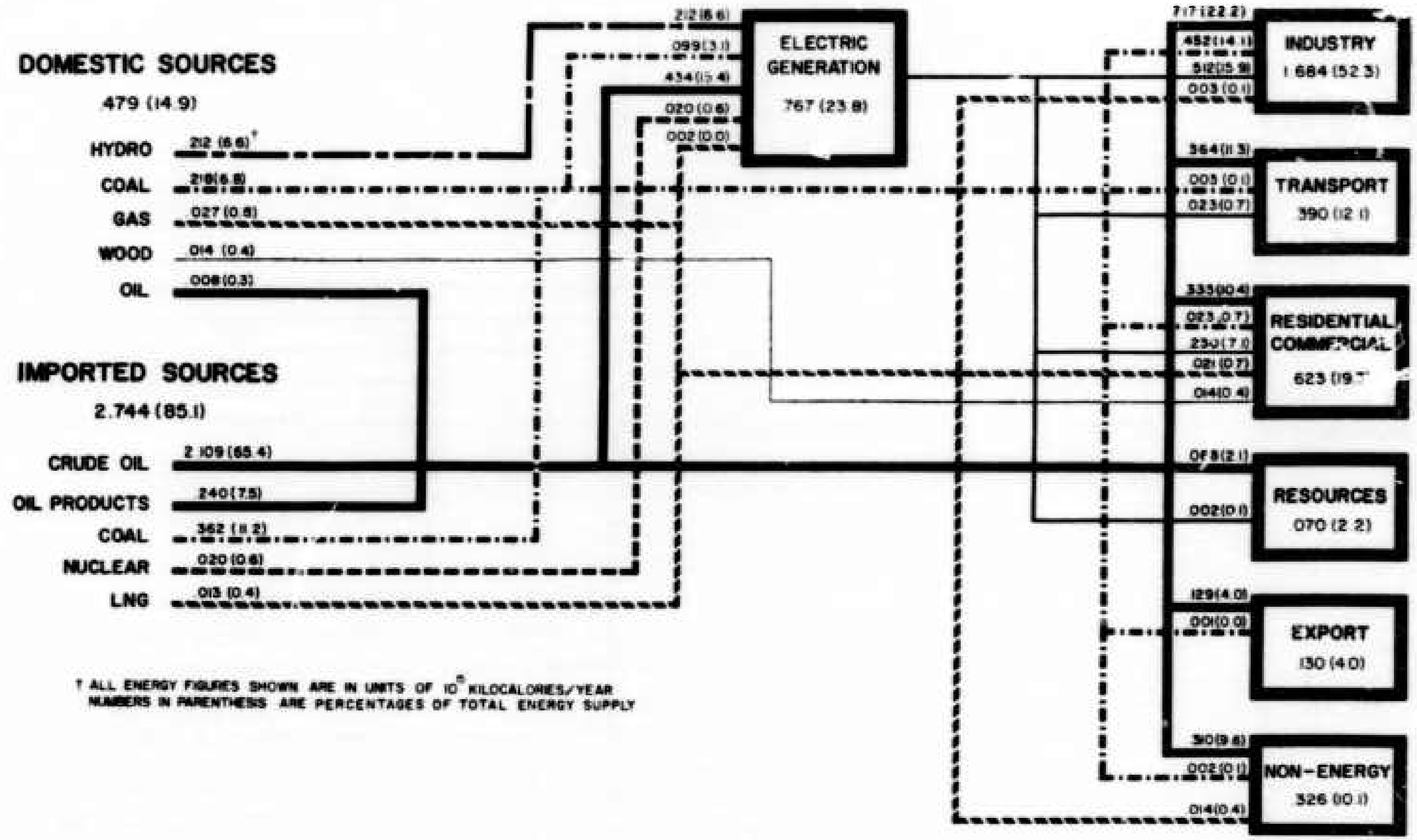

Figure 4.1. Japan Energy Balance in 1971, Total Energy Supply = 3.223 x 10^{15} kilocalories/year

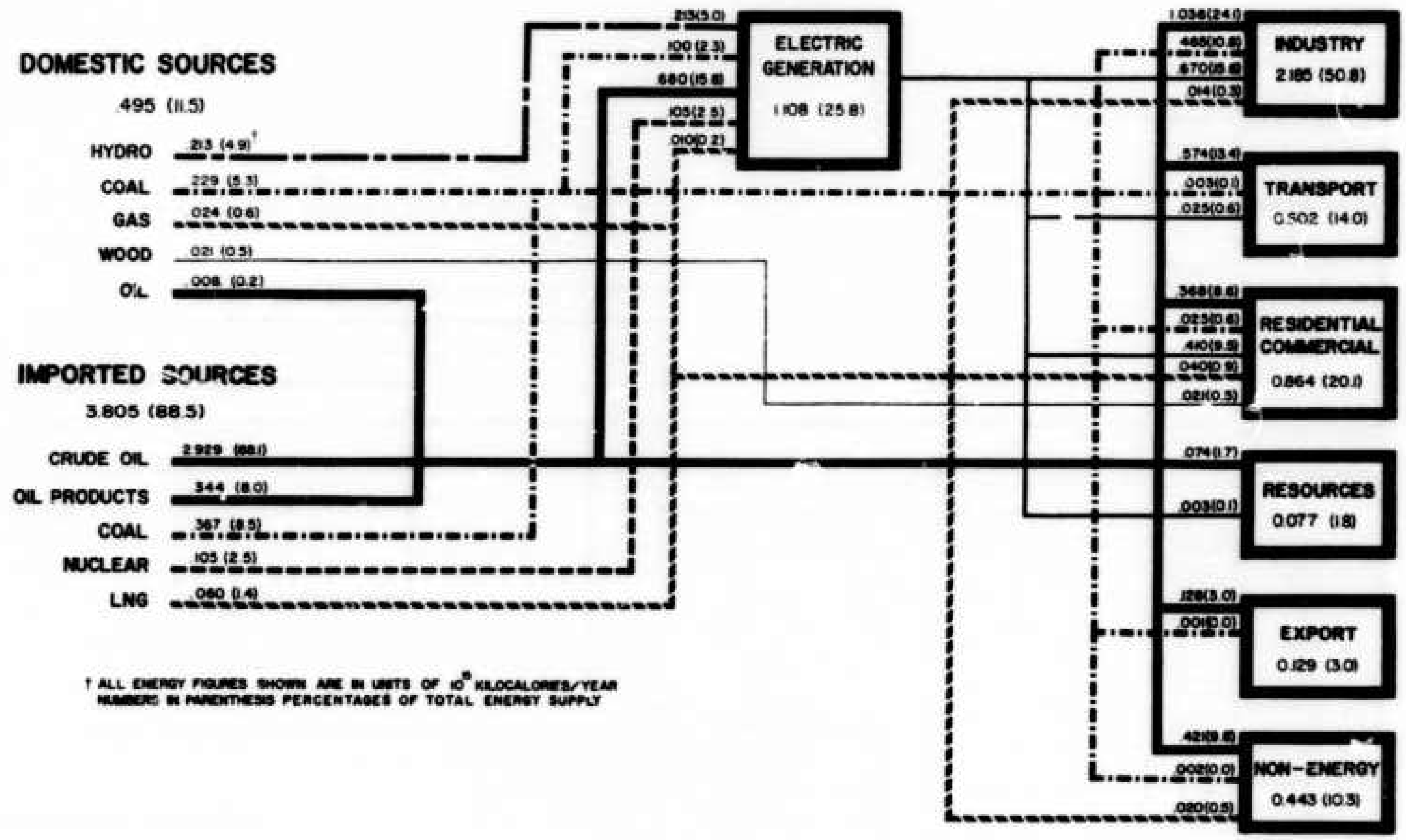

Figure 4.2. Japan Energy Balance in 1975, Total Energy Supply = 4.3 x 10^{15} kilocalories/year

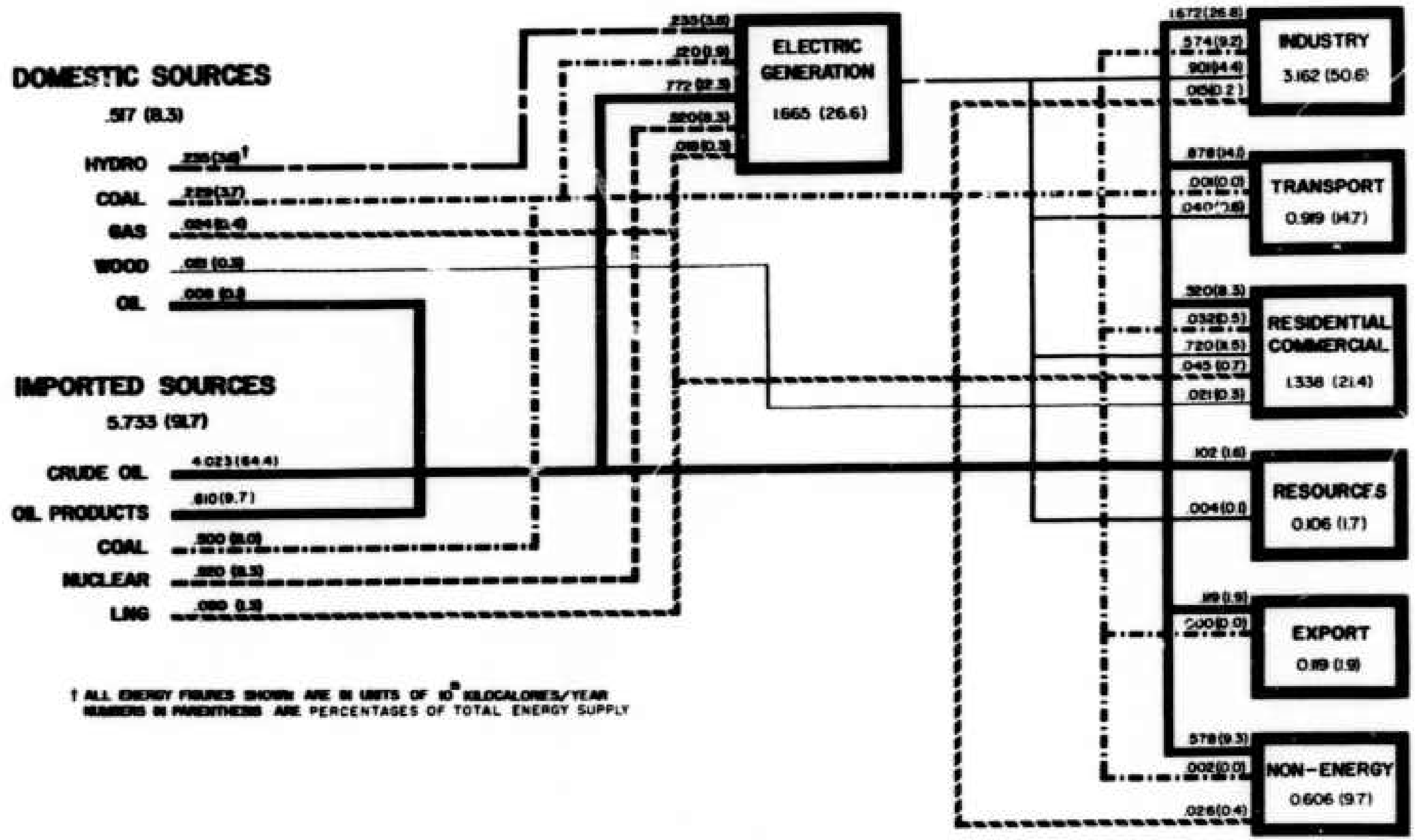

Figure 4.3. Japan Energy Balance in 1980, Total Energy Supply = 6.25×10^{15} kilocalories/year

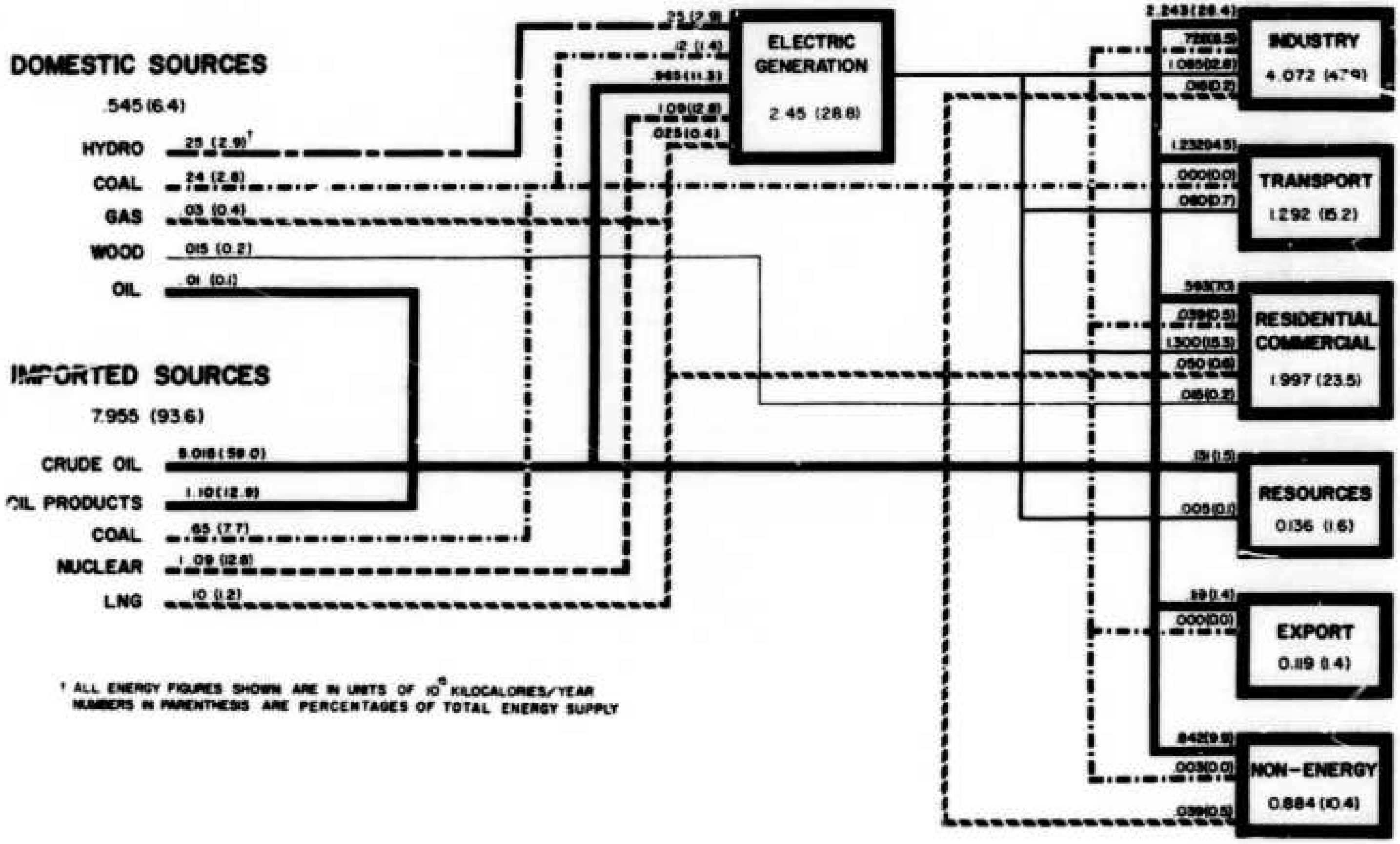

Figure 4.4. Japan Energy Balance in 1985, Total Energy Supply = 8.5 x 10^{15} kilocalories/year

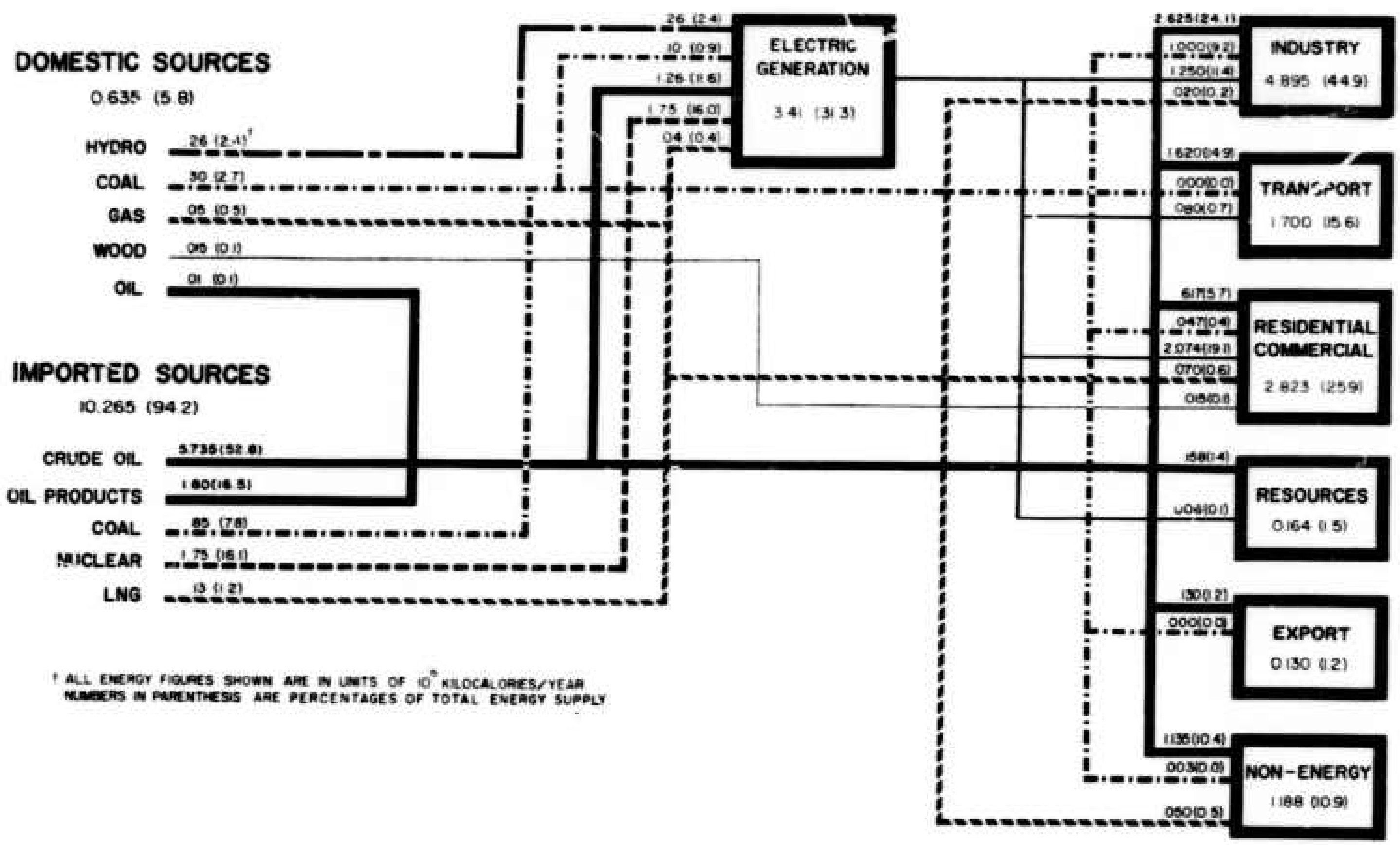

Figure 4.5. Japan Energy Balance in 1990, Total Energy Supply = 10.9 x 10^{15} kilocalories/year

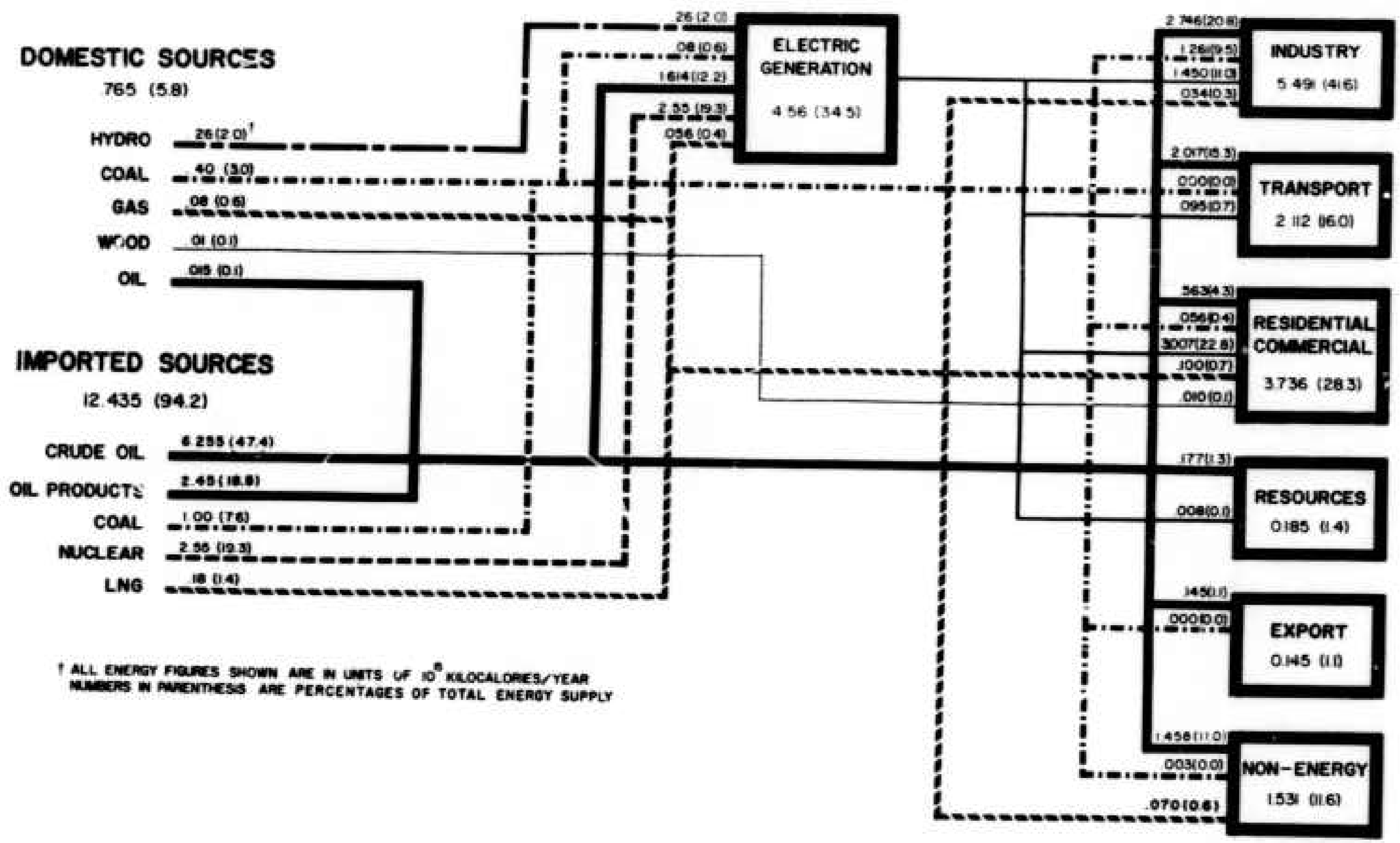

Figure 4.6. Japan Energy Balance in 1995, Total Energy Supply = 13.2 x 10^{15} kilocalories/year

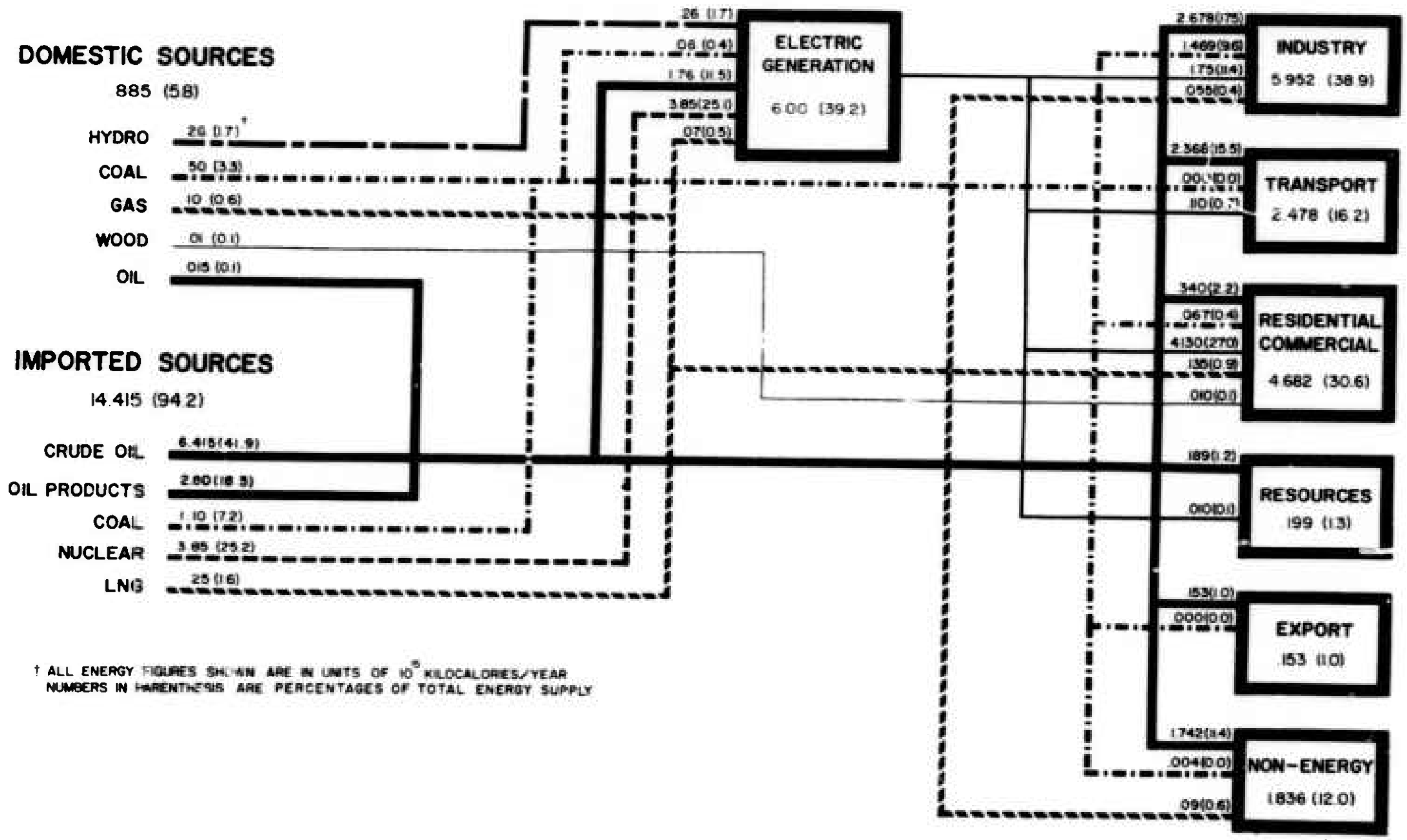

Figure 4.7. Jupan Energy Balance in 2000, Total Energy Supply = 15.3 x 10^{15} kilocalories/year

4.3 Supply/Demand Sensitivities

The input/output model mentioned above consists of a series of matrices (for each of the three energy growth cases considered and for each time period) which define the quantity of each fuel required for the various consuming sectors. The matrix for the 1985 base case was used to prepare Figures 4.8 and 4.9. Figure 4.8 shows the change in energy available to each consuming sector per unit change in oil supplies. Thus, if oil supplies were reduced to a value 10 percent less than was required, then industry would be short 6.6 percent of its required energy and the residential and commercial sector would be short by 5.5 percent. Transportation, non-energy, agriculture and export would be short almost the full 10 percent as a consequence of the almost total dependence of these sectors on petroleum. (The absolute energy requirements of each sector may be determined from Figure 4.4).

Figure 4.9 shows the change in fuel requirements per unit change in the energy requirements of the industry sector. Thus, if the energy requirements of industry were to increase 10 percent each energy resource with the exception of wood should increase. The required increases are: oil, 4.4%; coal, 8.8%; gas, 2.1%; and, hydro and nuclear, 4.4% each. The simple model does not take into account the fact that hydroelectric power capacity is almost saturated or that there is a considerable time lag in getting nuclear power online. These deficits would probably have to be made up by oil, coal, or gas.

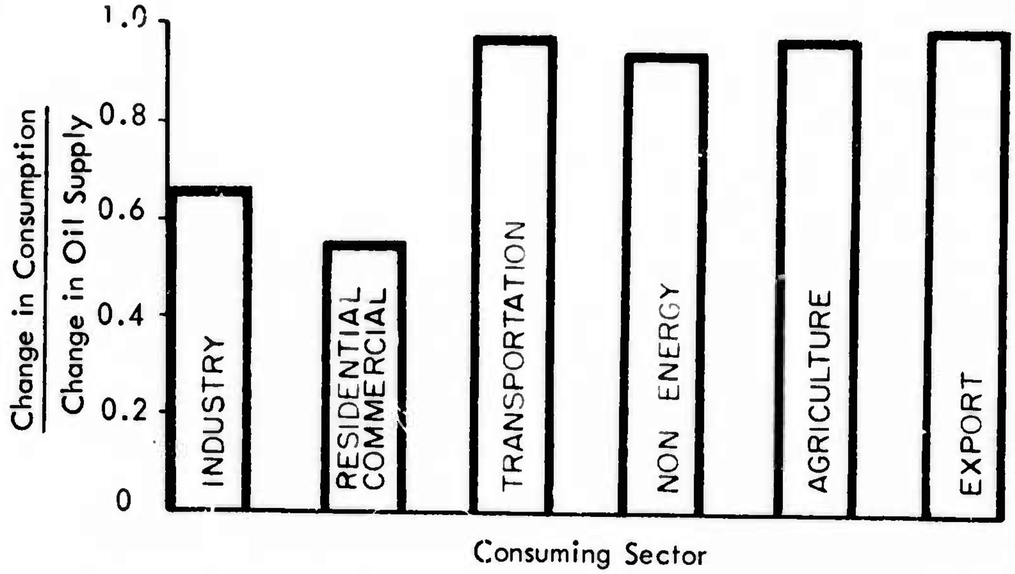

Figure 4.8. Sensitivity of Energy Consumption to Change in Oil Supply (1985 Base Case)

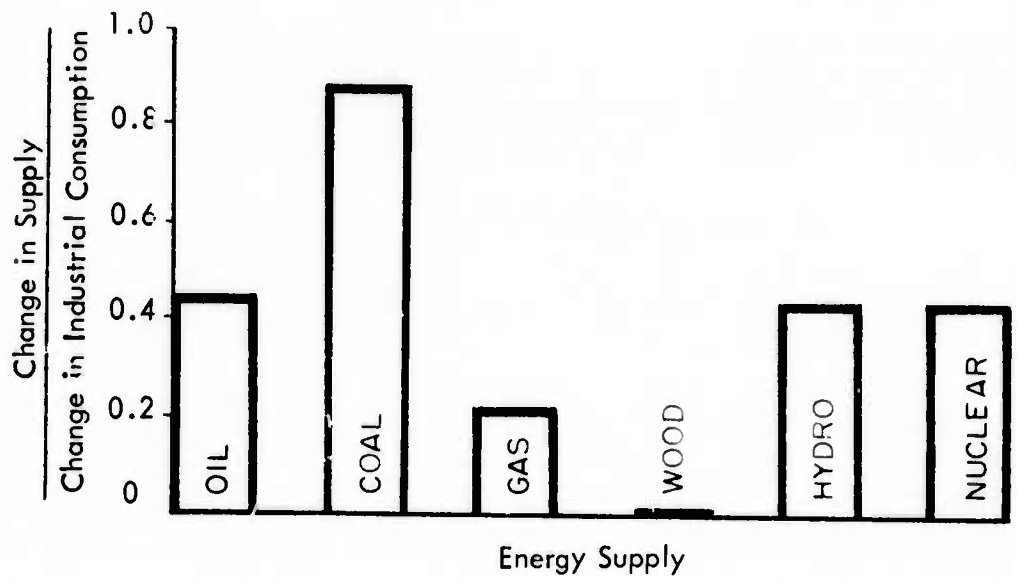

Figure 4.9. Sensitivity of Energy Supply to Change in Industrial Consumption (1985 Base Case)

Section 5

GEOPOLITICAL IMPLICATIONS OF JAPAN'S CURRENT AND FORECAST ENERGY REQUIREMENTS

5.1 General

Sections 2 and 3 have demonstrated that Japan is presently dependent upon imported oil to meet her energy requirements. This situation is forecast to extend, without mitigation, through the year 2000. No major technological developments are expected that will change the forecast scenario, although some relief is expected in increased nuclear electrical power generation resources. Nuclear power plant construction (as in the United States) has not proceeded at the pace anticipated in earlier forecasts, and as Japan's energy demands continue to escalate, her access to imported petroleum and petroleum products is expected to be pivotal to industrial, commercial, and residential progress. Thus any event or series of events that could cause even minor perturbations in the availability of imported oil would have serious repercussions on her economy.

Japan is keenly aware of the consequences of not being able to satisfy her energy requirements and is covering all bets, as it were, to minimize her risk. As oil represents the largest component of her energy supply, most of Japan's efforts have been directed toward securing stable flow of petroleum from sources which are diverse in geography, geology, and political ideology. To be sure, she is actively developing nuclear power, and natural gas resources, and is concerned about mitigating the environmental effects of all forms of energy production. However, Japan is not alone in her quest for energy. Of the major developed nations, only the Soviet Union is self-sufficient in terms of domestic energy resources. The competition for resources in limited supply is expected to be severe. The question is whether or not Japan's situation could deteriorate to the point of involving the U.S. in an international conflict.

It is difficult to postulate situations arising directly from the "energy crisis" which could lead to armed conflict of consequence. A possible exception is the Middle East, but here it is very difficult to separate an energy-related scenario from yet another manifestation of the Arab-Israeli conflict. The energy crisis does seem to offer enumerable opportunities for severe economic competition and/or minor skirmishes; however, the major powers are developing a sufficient number of options that they will not be dragged quickly into war. Japan herself does not have extensive armed forces and traditionally has underwritten foreign Japanese business losses rather than attempt to defend them with force. Because an energy crisis will strike close to the economic heart of the countries involved, even minor skirmishes could have serious consequences and potential trouble spots should be carefully watched.

In this section Japan's relations with Persian Gulf countries are examined followed by a discussion of Persian Gulf-to-Japan oil transportation in terms of tankship requirements, tanker routes and a potential trouble spot — the Straits of Malacca. The effect of Japan's energy requirements on her relationship with the Soviet Union, the Peoples Republic of China, and United States is examined and finally potential conflicts arising from offshore oil exploration are identified.

The cause and effect relationships between energy shortages and potential conflict cannot be well enough defined to treat explicitly the impact of high case versus base case energy demand projection. If Japan's energy demands follow the high case, the competition for oil can be expected to increase even more rapidly. On the other hand, a major oil find in the Yellow Sea could insure adequate petroleum supplies worldwide until fusion power is developed.

5.2 Japan and the Persian Gulf

5.2.1 General Observations

Japan currently acquires approximately 85 percent of her crude and about half of her oil products from the Persian Gulf; the amount which comes from the Far East makes it a poor second (see Table 2.1). Hence Japan has a great interest in this vital area which may not always be complementary to U.S. interests in the same area. As is discussed in greater detail in Appendix C (Volume II), the central theme of the Japanese Government energy policy is to secure and maintain the economic availability of oil supplies. A major national goal is to rectify the current imbalance in the control of petroleum resources so that the exploration, development, transportation, and to a significant extent, refining of Japan's imported energy sources will be under either direct or indirect Japanese control. At the moment, approximately 80 percent of Japan's oil supplies are controlled by foreign capital and corporations. Japan's objective is to reduce this to 30 percent by 1985.

Much of this imbalance lies in the Middle East and the Persian Gulf states in particular which is the area where Japanese firms are making the strongest bids to achieve wellhead-to-consumer control of petroleum. At the same time, the Japanese are taking equally vigorous steps to expand geographically their sources of oil so that possible events beyond their control in the Persian Gulf would not shut off the bulk of their supplies. Southeast Asia is the area in which Japanese-controlled and Japanese joint ventures with foreign exploration companies are most active. Goals stated by MITI are:

- 85% dependence upon the Middle East 1972 (current status)
- 80% dependence upon the Middle East 1980
- 55% dependence upon the Middle East 1985
- generally lessened overall oil requirements post 1985, with nuclear power in the ascendency, and a projected slowdown in growth rate.

However, it should be noted that these goals are stated in percentage terms and do not reflect the absolute quantities in barrels of oil per year that Japan will require during the same time periods. As discussed earlier, the absolute quantities of crude that will be required by Japan in 1980 will be just about twice those imported in 1971 (see Figure 2.1). Hence the import total from the Middle East (90 percent of all oil imported) was 14 billion bbl. On the basis of the SAI base case, it will increase to 24 billion bbl in 1980. So even if the 1985 goal of only 55 percent dependence upon the Middle East is achieved, the quantity of oil required from the Middle East will continue at 1980 levels. We can logically assume that Japan will take appropriate steps to assure the maintenance of this important supply. This need has been behind Japan's reluctance to join an "anti-OPEC" group, sometimes referred to as an "oil consumers lobby" that the United States and Western Europe are promoting. Japan has stated both publicly and privately that she chooses to preserve her economic options in this case and will not be bound by actions taken by a consumer lobby that might be to the detriment of Japan's economic and possible geopolitical interests. This attitude is viewed by some as the opening shots of economic warfare in which Japan with a strong foreign trade position could outbid the United States in much of the Middle East, and could, if necessary compete vigorously with the stronger countries of Western Europe. Others view this position as essentially pragmatic logic, in which Japan's national interests predominate.

5.2.2 Current and Potential Geopolitical Factors

It is difficult in 1973 to postulate a credible geopolitical scenario in which Japan is engaged in hostilities of even minor intensity in order to protect her petroleum sources in the Persian Gulf. Conflict or confrontation by surrogate, however, is another matter, as Japan underwrites and continues to acquire holdings in the Gulf area; but lacking an armaments industry, Japan would not be able to provide such states with either offensive or defensive weapons. However, a "mini-arms race" seems incipient in the Middle East, and the oil-rich nations have the funds to purchase modern weaponry from any potential vendor, regardless of political ideologies. In addition, Iraq has emerged as the Soviet-sponsored counterpoise to U.S.-supported Iran, and has already engaged in minor skirmishes in Kuwait.

Japan could use her tremendous economic leverage and favorable foreign trade position to exert influence in the Persian Gulf if necessary. In what may be described as a "carrot and stick" capability, a typical "carrot" might be an offer to build a refinery for one of the oil-supplying nations in exchange for guaranteed access to petroleum supplies. Advantageous pricing and turnkey operations of a tankship fleet for some of the oil-producing nations are other economic lures available to Japan; the ultimate lure is simply outbidding other countries in a form of economic warfare. The "stick" capability is less obvious, and may take the form of economic and technical support of a rival sheikdom, where appropriate, rather than application of punitive measures.

Japan also has considerable influence in the Gulf, external to elements of the petroleum industry. In nations where money is plentiful, she might offer such things as a modern communications systems, an internal television capability, terminal and pier construction, office building construction, air-conditioning equipment; the list is literally endless, and can be tailored to each state's requirements. For example, the tiny neutral zone of Ra's Al Khafji recently produced a set of handsome postage stamps featuring historic Japanese steam locomotives, obviously a "service" performed by Japan, since Ra's Al Khafji has no railroad, probably 99 percent of the population has never seen a locomotive, and its postal requirements are minimal. Japan does, however, maintain a considerable presence through the Japanese Arabian Oil Company, and operates a sizable offshore development field.

5.2.3 Japanese Activities and Acquisitions in the Persian Gulf

As stated above, the central theme of the Japanese Government energy policy is to secure and maintain the availability of oil supplies. No where is this policy more evident than in the Persian Gulf, as for example:

- Abu Dhabi: Abu Dhabi is the source of 7.9 percent of Japan's Middle Eastern imports and represents Japan's most intensive penetration into full exploration and development control. The Abu Dhabi Oil Company is a consortium of Japanese companies that have been very successful in exploration and production, primarily offshore.

- Iran: Iran is the source of 50 percent of Japan's Middle Eastern imports. A group of Japanese formed the Iranian Petroleum Corporation and were granted exploration in a promising but as yet undeveloped area. Japan does not maintain control of the bulk of her Iranian supplies, but the willingness of the Imperial Iranian Government to grant concessions of this nature indicates that Iran is willing on a joint venture basis with the National Iranian Oil Company to accommodate the Japanese in this area.

- Kuwait-Saudi Arabia-Neutral Zone: Japan receives 38.4 percent of her Middle Eastern oil and 31.9 percent of her world oil supplies from these three states through the operations of the Japanese Arabian Oil Company (AOC). The AOC operates a 30,000 bbl/day refinery at the Ra's Al Khafji terminal, as well as a 500,000 bbl/day pipeline servicing the extensive offshore fields. The AOC has been operating since 1961 and continues active exploration in potentially prolific areas. Collectively, this region represents Japan's strongest investment in the Gulf.

- Qatar: Although Qatar produces only a very small portion of Japan's imports from the Persian Gulf (less than 1 percent) the Qatar Oil Company, a consortium of seventeen Japanese companies, has been granted a 3000 square mile concession offshore and to the east of the Qatar Peninsula which shows considerable promise.

5.2.4 LNG from the Persian Gulf

Another significant element in Japan's future energy plans is an extension of her imports of liquified natural gas. As detailed in Appendix D, increased imports of LNG figure prominently in Japanese energy resource planning, even though total LNG imports by 1980 are projected to amount to only 3 percent of the energy derived from petroleum. Japanese imports of LNG are currently restricted to firms in which Japan has either full ownership or a controlling interest. Current supplies are from Alaska and Brunei, but Abu Dhabi is prominent in Japan's plans for the use of this fuel. As has been previously mentioned, Japan has established considerable economic influence in Abu Dhabi, and will import LNG from Japanese-owned and -operated facilities. Three million tons per year are scheduled to be shipped from Japanese-owned terminal and liquification facilities on Das Island, drawn from the extensive offshore reserves under development in Abu Dhabi.

A commitment to a joint venture in LNG production and shipment to Japan was established with Iran. However, the economics of the development led to postponement of activities in 1972. Since Iran has considerable gas reserves, it is logical to assume that, in addition to supplying crude and petroleum products, Iran will become an important supplier of LNG to Japan. The situation and forecast is further detailed in Appendix D.

Japanese exploration and development teams are active throughout the Gulf, since oil and gas are traditional geologic neighbors. Concurrent with oil exploration the Japanese Arabian Oil Company is conducting exploration for gas offshore of the Neutral Zone, and elsewhere in the Gulf. Firm plans are not known concerning development of deposits where encountered, since the liquefaction and transport facilities are very expensive undertakings and must be justified (as in the case of Abu Dhabi) by extensive proven reserves. The potential significance of the Gulf as a supplier of LNG to Japan by the 1980-2000 period should not be overlooked.

5.2.5 Outlook

Japan's presence in the Persian Gulf is obvious and increasing. Through the use of joint ventures or consortiums, or as a result of outright ownership, Japan is assuming a major role in the Gulf. She is in a position to outbid, on a dollar/bbl basis, the United States and several states of Western Europe. Although there have been isolated incidents of such economic pressure, the traditional suppliers (primarily to Western Europe) have honored their previous agreements, although some have given way to the higher prices offered by Japan. Should, for example, Saudi Arabia yield to pressure exerted by other Arab nations in the U.S.-Israel policy, Japan would be a ready market for oil denied to the United States. Iran, on the other hand, a primary supplier of Japan and a potential primary supplier to the United States, could counter this move by increasing supplies to the U.S. at the expense of Japan. Iran's dependence on the United States for maintenance spares to her extensive inventory of advanced-technology weaponry acquired within the past 18 months, could for example, easily lead to the realization of such a scenario. Japan has influence — even strength — in the Persian Gulf. One particular strength of Japan is that she has taken no position of advocacy of either the U.S. policy of support of Israel, or of the hardening of their position toward the U.S. by the Arab states. If (as is threatened), the Arab nations either refuse to expand their oil production, or more seriously, boycott shipment of oil to the U.S., Japan is in a unique position to move in and absorb the U.S. requirements. An ancillary role that could be played by Japan is identical to that advocated by the head of the White House

Energy Policy Office, John A. Love. On 12 August 1973 in a television interview Governor Love suggested that the U.S. could aid dollar-rich but material goods-poor Arab nations by developing useful investments and expenditures for their dollar holdings. Such activities would not necessarily be in the downstream management of their oil distribution, but could include investments or real estate. Japan is in a similar position which is slightly weaker since she too holds large dollar reserves which she is looking to invest.

5.3 Petroleum Transport

5.3.1 Tanker Requirements

Between 1971 and 1985 Japan will need to increase her imported oil supplies by approximately 3.8×10^{15} kilocalories.* Based on an average energy content of 9400 kilocalories per liter, this forecast translates into approximately 400×10^{6} kiloliters of oil (2.5×10^{9} bbl) or approximately twice the 1971 level. As can be seen in Figure 5.1, this quantity amounts to an annual increase in demand of about 26×10^{6} kiloliters of petroleum and products between 1973 and 1980, and about 31×10^{6} kiloliters per year between 1980 and 1985.

It is interesting to convert these import requirements into required tankship deadweight tonnage. In tankers under 100,000 dwt a conversion factor of 7 bbl per deadweight ton of ship can be used; for tankships in the 200,000 dwt range, the factor is closer to 7.5 bbl/dwt; and for tankers in the 500,000 dwt range (there is only one now

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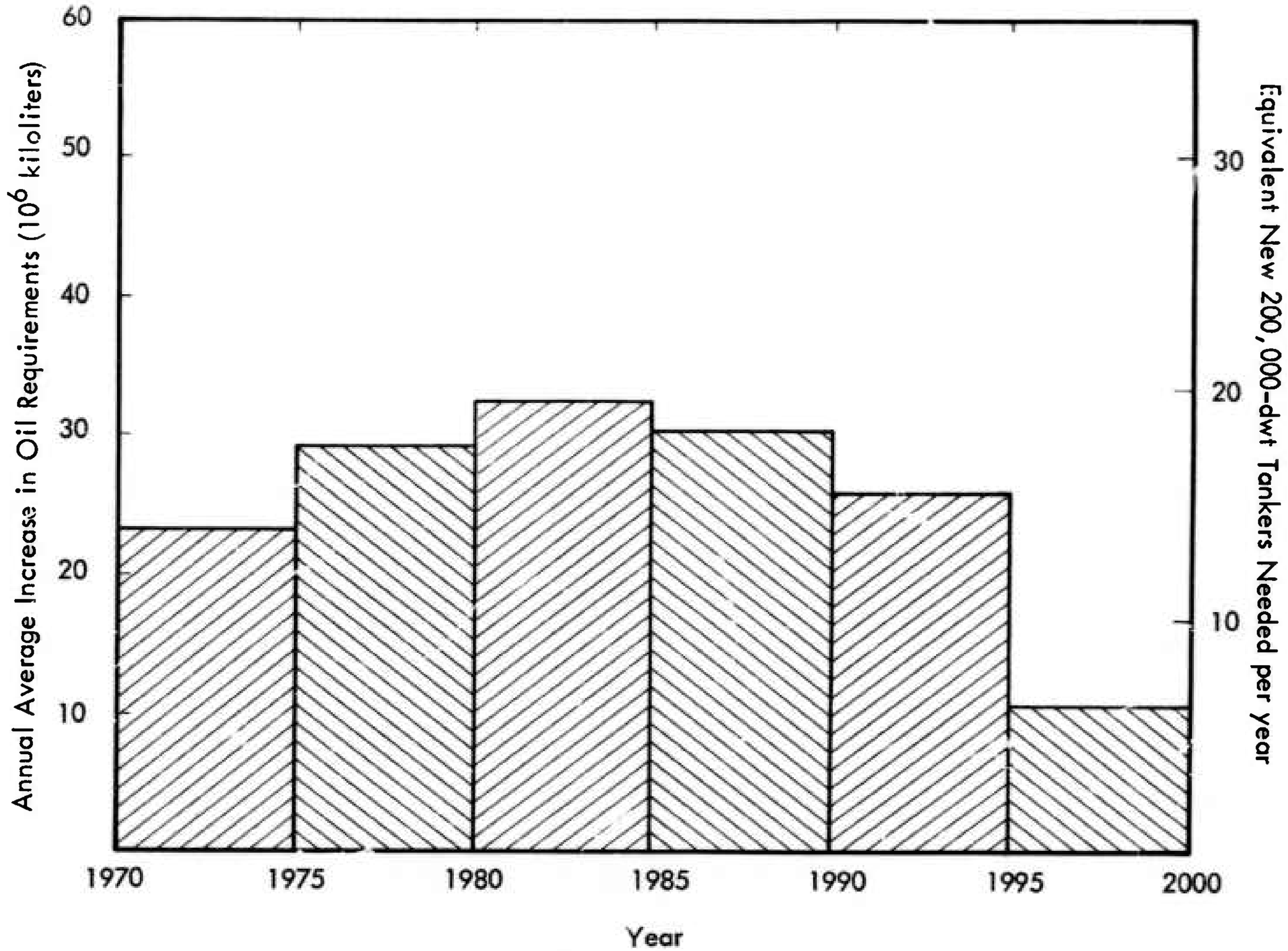
* Unless otherwise stated, all data presented in this section are predicated upon base case of economic growth and resulting energy requirements discussed in Section 2.



NOTE: 1971 total requirements were about 250 x 10^6 kiloliters.

Figure 5.1. Yearly Increase in Imported Oil Supplies Needed by Japan to Meet Demand

in existence, the Globtik Tokyo at 477, 000 dwt), a figure of 8 bbl/dwt is considered acceptable. Because of port restrictions (which are discussed below), and patterns of acquisition and charter of tankships currently in the Japanese petroleum trade, tanker requirements are expressed in terms of 200, 000 dwt ships. In practice, the tanker fleet will consist of a mix of ship sizes and the ships larger than 200, 000 dwt are in general offset by the use of smaller ships. Figure 5.1 graphically presents not only the increased petroleum imports but also converts them into 200, 000 tanker equivalents, representing the number of additional 200, 000 dwt tankships that must be added to Japan's merchant fleet (either by construction or charter) each year. It may be noted that about 18 additional 200, 000 dwt tankers must be added to the Japanese petroleum transport traffic per year through 1995. The calculations of tanker requirements are based on a nominal seven roundtrips per year (all to the Persian Gulf) each of 50 days duration.[16] A 10 percent allowance has been made for factors such as repair, lags in construction, strikes, and other unscheduled delays.

Beyond 1985 the projected slowdown in the rate of economic growth, and forecast increase in the use of nuclear power for electric power generation will have an impact on petroleum demand. Japan's annual requirements for new and additional tanker tonnage will continue to decrease until some time beyond the year 2000, when the rate of total national requirements for petroleum and petroleum products will begin to level off. Thus, when establishing requirements for tanker tonnage, superports, shoreside handling and storage facilities, and internal terminals and pipeline facilities, the greatest "crunch" for Japan is likely to occur about 1985.

5.3.2 Ports and Terminal Facilities

Even if Japan continues her present course in diversifying sources of crude and petroleum products, ports and terminal facilities for VLCCs and ULCCs will remain as a limiting factor. Economy of scale favors the use of the supertanker even if the source of crude shifts from the Persian Gulf to nearby fields in the South China Sea or Indonesia. Prime Minister Tanaka makes the point graphically when he states in Building a New Japan:[3]

> "Taking petroleum for example, Japan brings 92 percent of its total imports from Middle East sources which are more than 5,000 miles away. However, with 300,000-ton tankers, the transportation costs come to about $3.30 per ton of petroleum. This is about the same as the domestic shipping costs between Tokyo Bay and the Inland Sea. Thanks to the use of giant tankers, it is just as if Japan had the world's largest oil field within its own borders. . . ."

Prime Minister Tanaka, possibly somewhat unrealistically, sizes his fleet requirements in terms of 500,000-dwt tankers when he states: ". . .assuming that Japan's 1985 demand for petroleum will reach 700,000 tons per year,* it will be necessary for the Japanese ports to handle a total of 1,400 entries of 500,000-ton tankers annually. This comes to 3.8 fully-loaded 500,000-ton tankers calling at Japanese ports every day. . . ." The Prime Minister then goes on to make a logical case for massive port and tanker terminal expansion.

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* The Prime Minister's estimate of Japan's petroleum import requirements also appears to be high and is definitely higher than the "highest" projections developed in Section 3 and more than twice the base case projections used to establish tankship requirements in Figure 5.1.

In contrast with the Prime Minister's position are those that maintain that for Japan tankships in the 200,000 to 250,000-dwt range will essentially be optimum basic petroleum transportation for Japan. Current order books seem to bear out this hypothesis, although a significant number of ships in the 300,000-dwt range are either on the ways or on order, while less than ten in the 400,000-dwt and up range are either being built or on order. The proponents of the 200,000-250,000-dwt class maintain that ships of this category are large enough to be economical in operation, and small enough to be accommodated in either present or upgraded ports in Japan. Currently, only one port on the Japanese Home Islands can accommodate ships of the 500,000-dwt type, and three others are either undergoing expansion or such expansion is in the planning stage. The one port currently capable of accepting ULCCs — Kiire in southern Kyushu — has minimal transfer facilities and requires that crude be transshipped to smaller tankers for distribution throughout Japan. Okinawa is another port that can accept the ULCC, but here again, storage and transshipment are required If the objective of one ULCC terminal on each of the Home Islands was achieved, the most likely candidates would be Kiire on Kyushu, Yokohama on Honshu, either Hakodate (in port) or Tomakomai (offshore buoy unloading facility) on Hakkaido, and Tokushima on Shikoku. Other ports, particularly those on the Inland Sea and the Japan Sea coast, could be best served with tankships in the 200,000-250,000-dwt range.

At the same time, it is premature to judge that there is no role for the 300,000-ton ship (many on order worldwide), the 500,000 tonner (four being built), the 700,000 tonner (on order), or even the million-dwt tankship (on the drawing boards). As long as the Persian Gulf remains the mainstay of Japan's imported petroleum, economy dictates the use of the largest ship feasible at both loading and discharge terminals. However, a logical fleet mix with a large population of smaller ships seem preeminently feasible. At this writing, the Japanese petroleum industry and tankship builders seem to be covering both options. The case for the 200,000-250,000-dwt ship is the present capacity of Japan's ports. Only six ports may currently accept ships of this category although at least three more may be expanded with minimal investment to accommodate VLCCs. The use of single point offshore buoys also can increase the number of ports that can accommodate the VLCC, but projections for the use of these facilities vary widely. Japan is frequently swept by devastating typhoons. Ships of the size of VLCCs and ULCCs, anchored at offshore buoys and moorings, are particularly vulnerable, even if sufficient swinging room is available. Particularly in the Inland Sea, and to a lesser extent on the Japan Sea Coast and on the coasts of South Hokkaido, sufficient swinging room for a VLCC in a typhoon is a serious problem.

In summary, it appears that port capacity can be a serious limitation to the use of ULCCs in any quantity in Japan, unless the concept of the central terminal station and subsequent transfer to smaller ships is used. On the other hand, if the philosophies and doctrines of Prime Minister Tanaka prevail, extensive port expansion and installations of offshore mooring buoys can completely change this projection. Ships in the 200,000-250,000-dwt range are expected by many to prevail, with a sizable fleet of the 300,000-dwt class serving those ports which were developed to accommodate vessels of this type.

5.3.3 Tanker Routes

A significant problem currently confronting Japan is the transportation of crude from the Middle East to Japan. Most tankers use the Straits of Malacca – a voyage of approximately 6800 nm. The largest tankers must use the Lombok Straits – almost a thousand miles longer voyage. The alternative route of sailing around southern Australia (≈14,000 nm) is not very attractive to the Japanese.

The Straits of Malacca are actually two major navigational channels located between the Malay Peninsula and the Indonesian Archipelego. The primary waterway may be considered to originate approximately at the Thailand/Burma/Malaysia border area, adjacent to the northern tip of Sumatra and extends approximately 500 miles in a southeasterly direction to the narrower (and more dangerous) Singapore Strait. The Singapore Strait extends southeast and then south around Singapore Island, and is bounded on the south and west by a series of small islands (and shoals) that comprise the Riau (Riouw) cluster or archipelego that lie essentially due south of Singapore. This Singapore Strait then makes a slightly northward bend and exits into the southern extension of the South China Sea, still over the continnental shelf, and still in an area of shoals and islands. The collective waterways are commonly referred to as the Straits of Malacca. Figure 5.2 shows alternative tanker routes from the Persian Gulf to Japan.

Maritime commerce in the Straits is heavy and burgeons every year. Singapore data record 37,000 ships of all sizes traversing the Straits in 1970[17] an increase of 5,000 from 1969. In excess of 40,000 ships were reported in 1971 and the traffic density continues to increase. A 1971-1972 Japanese traffic study indicates that a large

PERSIAN GULF TO:
Osaka via Malacca 6800 nm
Osaka via Lombok 7700 nm
Osaka via Bass 14,000 nm

ULCC TO:
Kiire, subtract 300 nm
Okinawa, subtract 400 nm

<100,000-dwt via Torres: 11,500

KEY:

1	Persian Gulf
2	Kra Isthmus
3	Straits of Malacca
4	Lombok Strait
5	Torres Strait
6	Bass Strait

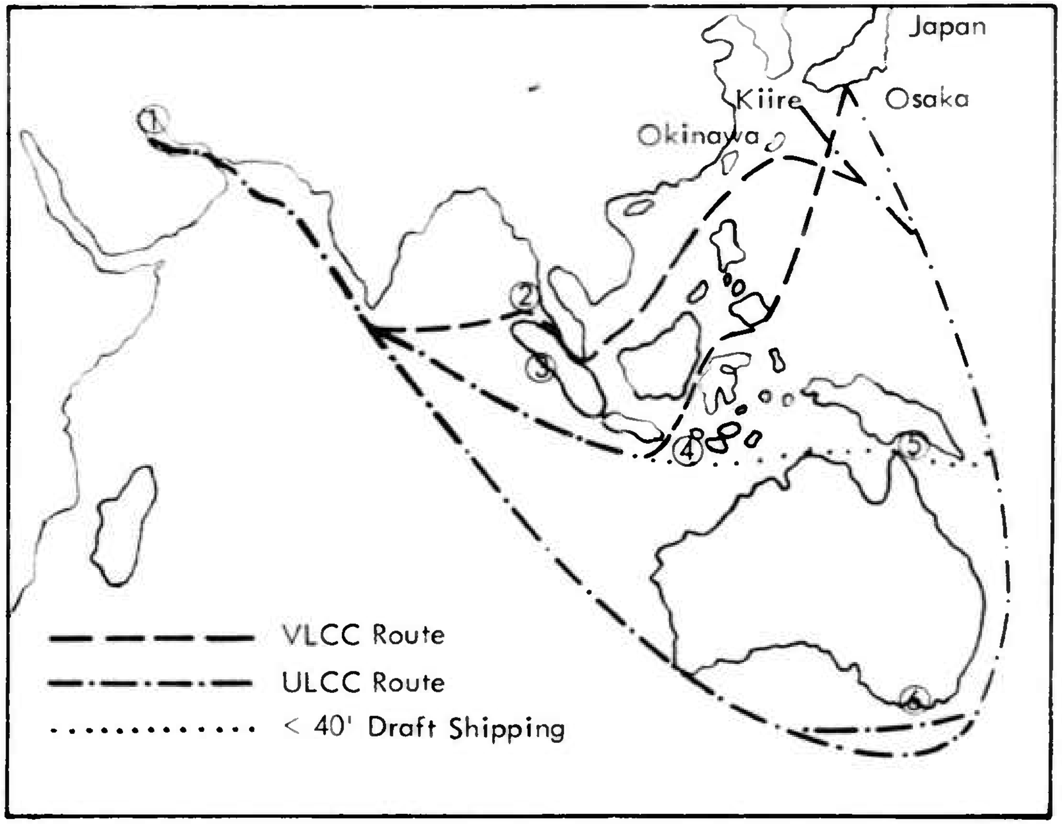

Figure 5.2. Alternative Tanker Routes from the Persian Gulf to Japan

supertanker on a 16-hour passage through the Straits encounters 40 ships larger than 2,000 tons. This does not include extensive trans-Straits ferry traffic, countless fishing sampans, and light coastal and commercial traffic. Since some of the trans-Straits traffic is smuggling (a profitable and active enterprise in these waters for the past thousands years), encounters with unlighted vessels of various sizes, and certainly under minimal maritime control, may be anticipated.

Significance of the Straits of Malacca to Japan. In 1971 the flow of oil from the Persian Gulf to Japan was of the order of 3.9 million barrels per day, or a requirement for approximately 600,000 dwt of shipping per day. The bulk of such shipping was in tankships of 200,000 dwt or less, which traversed the Malacca Straits. The remainder came via the Lombok Straits between the Indonesian islands of Bali and Lombok in 300,000-dwt class ULCCs. In 1967 however, the 150,000 dwt Idemitsu Maru, then the largest ship in the world, briefly touched bottom while traversing the Malacca Straits; pending completion of a detailed oceanographic survey, Japan routed subsequent vessels in the 200,000-ton category through the Lombok Straits as a precaution against accidental grounding. Such a procedure added significantly to the operating costs of ships that could marginally use the Malacca Straits and prompted the following developments:

- Immediate institution of a detailed route survey of the Malacca Strait, the Singapore Strait, the Lombok Strait, the Makassar Strait, and areas where there was potential danager of stranding in the sea lanes of the South China Sea. The survey was carried out by Japan with the reluctant cooperation of the neighboring nations.

- Interest by Japan and Thailand in the construction of a pipeline across the narrow Isthmus of Kra, in the Thailand, Burma, North Malaysia area.

- Statements by the foreign ministers of Indonesia and Malaysia that the Straits were territorial waters and subject to the controls that might be imposed by bordering nations.

- Statement by the Prime Minister of Singapore that the Straits were, in fact, international waters, and that the right of free and innocent passage of ships of all nations should be permitted. *

- Strong statement by Japan (and acquiescence by the U.S.) that the Straits were international waters, backed up by subsequent statements of the Joint Chiefs of Staff and by passage of U.S. Naval vessels through the Straits during the India/Pakistan confrontations.

- Renewed interest, by Thailand, in a canal across the Isthmus of Kra, a project that had been discussed literally for the past century and had been either encouraged or discouraged by various monarchs and later governments of Thailand.

The subject has become of even greater interest to Japan since her ongoing shipbuilding program consists primarily of the VLCC and the ULCC. In the case of the ULCC, the transit of the Straits is essentially academic since these vessels can use the Straits at most on the return voyage, and even then with some reluctance (see Table 5.1). It is in the 200,000-250,000-dwt category that the incipient problem lies for Japan. At this writing, 35 tankships in the Persian Gulf service in excess of 200,000 dwt but well under the 300,000 dwt range traverse the Malacca Straits. The draft of these ships is approximately 65 feet when loaded with Persian Gulf crude. The diversion

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* It may be suspected that this statement was made less in the interests of safety of tankships in the Straits than by the fact that Singapore has five oil refineries, dependent upon tanker supply through Malacca and a large ship maintenance facility.

Table 5.1. Distances from Persian Gulf Oil Sources to Japan in the Context of Tanker Dimensions

Tanker dwt (Range)	Draft in Feet (Cargo)	Port Limitation*	Preferred Routing		Approximate Round Trip Mileage (nm)
			Cargo	Ballast	
50,000	40	All	Malacca	Malacca	13,200
100,000	50	80%	Malacca	Malacca	13,200
150,000	60	40%	Malacca	Malacca	13,200
200,000	65	40%	Malacca**	Malacca	13,200
250,000	70	(S)	Lombok	Malacca	14,200
300,000	75	(S)	Lombok	Malacca**	14,200
350,000	80	(S)	Lombok	Lombok	15,300
400,000	85	(S)	Lombok	Lombok	15,300
450,000+***	100	(S)	Lombok	Lombok	15,300

* Although distances are computed from Osaka to Kuwait, port listing considers all ports of the Japanese Archipelego in which petroleum loading and storage facilities are located. Larger ships require more specialized unloading equipment, and harbor or offshore unloading space. The percent figures shown in this column indicate approximate number of Japanese ports capable of accommodating ships of size considered. The (S) indicates special "supertanker terminal" required.

** Passage to be negotiated under conditions of marginal safety and some navigational hazard.

*** Only one ship of this category is currently operational. Special modifications to existing "supertanker terminals" may be required, or offloading at Okinawa as is current procedure.

of these vessels (which are capable of traversing the Straits with extreme care in navigation, and under favorable conditions of wind and tide) to the Lombok Straits route would translate into 2-3 more days of sailing time per vessel, additional operating costs (depending on crew nationality, ship design, and manning requirements) of from U.S. $25,000 to $35,000 per day, and an obvious increase of the price of crude at the port of delivery.

In late July 1973, the threat of limiting traffic in the Straits moved a step closer to reality. Indonesia, Malaysia, and Singapore issued a "declaration in principle" that the Malacca Straits were territorial waters, and that the three states in concert had the authority to: (1) limit passage of VLCCs drawing more than 61 feet, and (2) establish a traffic control system in the Straits. Japan and the U.S. reaffirmed the right of innocent passage of the Straits, and no confrontation has yet occurred. Japan and flags-of-convenience nations operating tankships in the Japan-Persian Gulf trade have on order 60 tankers that will not qualify for passage under this restriction (excluding the ULCCs that would be consigned to the Lombok route in any event). In addition, currently under the Japanese flag are 35 vessels that, were the constraint to prevail, would be diverted to the Lombok Straits route. Finally, it may logically be assumed that traffic controls involving either queing, establishment of time of one-way traffic, or other procedures involving delays in passage will probably be instituted in the name of safety.

During the next year several significant repercussions could follow, should the doctrine of territorial waterway status for the Malacca Straits prevail. Canada and the Soviet Union, for example, have parallel situations in the Northwest Passage on the one hand and the Arctic Sea route on the other. The doctrine of the Bosphorus will undoubtedly be invoked, where the international status of that waterway, clearly within Turkish territorial waters, was affirmed. A major oil spill in the Straits, considered by many to be inevitable under present traffic, will certainly exacerbate the situation.

Potential Problems in Indonesian Territorial Waters. Indonesia and Japan are currently on very good terms and are active trading partners. Despite the fact that Indonesia joined with Malaysia and Singapore in the establishment of restrictions of traffic in the Straits of Malacca, Indonesia permits innocent passage of merchant shipping of all nations through the straits that separate the numerous islands of the archipelego. Of concern to Japan is, of course, the continuation of rights of innocent passage through the Lombok Straits. The straits are approximately 12 miles wide and are considered Indonesian territorial waters if the 12-mile offshore limit is accepted, but may be in doubt if a 3-mile limit is enforced (Indonesia claims the 12-mile limit and maintains that the Straits are in fact territorial waters). If necessary, Indonesia could extend the 3-mile limit from numerous small islands and islets within the overall confines of the Straits and could sustain her territorial waters claim. No nations have disputed the current Indonesian claim, and the fact that the Lombok Straits are Indonesian territorial waters is generally accepted.

Indonesia, however, ascribes to the "archipelego principle" which is not recognized in International Law at this writing, although it is currently under active discussion in the United Nations. In establishing this theory in practice, Indonesia claims all waters lying within established "baselines." The baseline concept is described in detail in publication number 35, issued by the Geographer of the Bureau of Intelligence and Research of the Department of State (July 20, 1971).

These claims were promulgated by the Sukarno Government in Februaray 1960, and were based on earlier Dutch Law (the Royal Territorial Sea Ordinance of 1939); however, they have neither been formally recognized nor contested.

Indonesia, with the Philippines and other countries that are primarily archipelegos, rather than a major land mass with outlying islands (Japan is conspicuously absent from this group) are currently strongly active in the current Law of the Sea conferences that are expected to continue worldwide until early 1975. Certain points germane to the use of the Lombok Straits have been submitted to the U. N. in a draft and are briefly summarized below:

- Archipelego nations are unique in geography and therefore have the right to impose certain contraints on marine traffice based on their unique status.
- Right of innocent passage of merchant shipping may be established by the nation in question except under conditions when national security is threatened.
- Warships may transit only under permission.
- Nations may establish appropriate sea lanes through the archipelego based on the nature of the transitting vessels, their size, maneuver characteristics, and cargo.
- Said sea lanes may be placed under appropriate traffic control and may require pilotage or observance of specialized rules of the road if deemed appropriate by the nation in question.

The draft protocol then goes on to discuss such matters as pollution controls, speed controls, environmental factors and similar matters. It must be stressed that: (a) the archipelego principle currently is not recognized International Law; (b) it has not been challenged, and (c) it has not been exercised. It represents what might be described as "an incipient threat in being." The probability of Indonesia exercising this right, particularly against Japan, is thought to be very low in the current international climate, even if the archipelego principle is accepted as International Law.

<u>Consequences of the Closure of the Lombok Straits.</u> Although the possibility is considered remote, the consequences of the closure of the Lombok Straits to ULCC passage could occur under two possible circumstances.

- A major tanker spill involving several weeks of clean-up could cause the waterway to be closed. ULCC captains and owners must then gamble on either an early opening (still paying costs of up to $35,000 per day while at anchor), or opt for the longer route south of Australia (see the following).

- A second possibility would be a change of government in Indonesia to one not friendly to Japan; a change in policy of the present government (judged unlikely); or one or more major spills in the Straits which have environmental consequences of such magnitude that Indonesia decides to close the waterway under the still-untested "Rights in Principle of Archipelego Nations."

<u>The Torres Strait.</u> The Torres Strait has, on occasion, been proposed as an alternative routing for ULCCs. Examination of even a small-scale hydrographic chart (U.S. N.O. 73026) indicates a massive population of islands, islets, shoals, coral reefs, and literally extensions of Australia's Great Barrier Reef. Extensive areas are marked "uncharted and presumed hazardous to navigation." Ruling draft appears to be 40 feet, thus ruling out all tankships in the VLCC/ULCC class that would normally use the Malacca, Lombok or even Sunda Straits. Although extensive U.S. Naval operations were carried out in this area

during World War II (e.g., the Coral Sea and Arafura Sea activities), even the largest naval units (battleships and heavy cruisers of both the U.S. and Japanese Navies)* did not require the depths of water under their keels of the VLCCs and ULCCs of 1973. Hence, for tankships in excess of 100,000 dwt, and with prudence, those in excess of 80,000 dwt, should not consider the Torres Strait as an alternative route.

The Bass Straits Route and the Tasman Sea Route. If the entire series of Indonesian Straits are closed, and a ship, because of draft cannot transit the Torres Straits, the only course of action remaining is a long southward arc around the entire continent of Australia, and passing through the Bass Straits between Australia and Tasmania, and thence through the Tasman Sea and north to Japan. Poor weather conditions may make it necessary to pass south of Tasmania itself. In rough figures, the 6500-mile voyage via the Lombok Straits will be increased to approximately 14,000 miles. The approximately 20-day voyages from the Persian Gulf will increase to nearly 40 days with attendant costs in fuel, crew expenses, and ship construction (for the larger fleet required). In short, the economic impact on Japan of the requirement to traverse the round-Australia route would be considerable — but the likelihood of this occurrence, based on the geopolitical climate of 1973 is very slight.

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* The "Iowa" class battleships, largest in the U.S. Navy, drew 38'; our heavy cruisers only 26'; and our light cruisers and destroyers from 18-25'. The "super-battleships" of the Imperial Japanese Navy, the "Yamato" and "Musashi" operated north of this area.

5.4 Japan and the Major Powers

5.4.1 Soviet Union

A strange geopolitical situation exists between the USSR and Japan despite burgeoning economic cooperation between the two nations. The two countries are still technically at war, as the USSR did not sign the Treaty of San Francisco,* formally ending the Pacific War phase of World War II. Russia moved into Manchuria and Korea during the closing weeks of the war, and defeated the Japanese Kwantung Army. Then, as the spoils of war, Russia occupied Karafuto (the southern half of the island of Sakhalin); the entire Kuril Island chain (including the two westernmost islands, Kunashiri and Etorofu, also traditionally considered part of Hokkaido); and the Habomai Islands, a group of four islands due south of the Kurils and their companion island Shikotan, a northeastward extension of the Habomai Peninsula of Hokkaido and traditionally governed by Hokkaido. Only the Kurils were awarded to the USSR at Yalta in 1945, but the geographic boundaries were not appropriately clarified at that time.

Throughout the 1950s there were several incidents such as shooting at "penetration of airspace" aircraft in the Habomai area and seizures of "trespassing fishing boats." Although tempers have cooled somewhat on the issue, it remains to be resolved and has inhibited the relations between the USSR and Japan, despite state visits and implementation of transportation services (e.g., JAL/Aeroflot trans-Siberian joint services). Prime Minister Tanaka has vigorously moved

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* The treaty was signed in September 1951 and came into effect on April 28, 1952. Japan "renounced her rights to the Kuril Islands and to southern Sakhalin but did not transfer title to the Soviet Union, who had been promised these territories at Yalta and was now in occupation."

toward normalization of relationships with the USSR, and has appeared willing even to "table" the northern islands issue in the context of the wider advantages of economic and energy cooperation. News stories surrounding the Prime Minister's latest visit to Washington, indicate a high probability of a joint U.S.-Japan-USSR energy effort, primarily in the LNG area (see also Appendices C and D).

The territory jointly claimed by the USSR and Japan, but de facto occupied by the USSR, assumes significance in the light of ongoing oil explorations along the Hokkaido continental shelf even though currently granted concessions do not impinge upon the disputed territory. Both Japan and international groups (non-Japanese firms as minority partners) have been participating in the exploration. There are signs that such activities could be rewarding; if significant finds occur, the exploration areas could easily extend into disputed territories and territorial waters.

Independent of territorial claims, and strictly in the context of an import-export business arrangement, Japan has imported a very small quantity of oil from the USSR Black Sea fields for a number of years. However, as described in greater detail in Appendix C, the oil development potential of Western Siberia, particularly in the Tyumen Province area, has brought a very significant supply of oil tantalizingly close to Japan. Access to these reserves, through development and pipelines could greatly change the geopolitical balance of the area. It is not anticipated that the Siberian industry will develop to a magnitude sufficient to require more than a small fraction of the output of potential giant oil fields discovered over the past few years. Therefore oil supplies both for Japan and for the Western United States are highly possible from this region. Joint USSR/Japanese/U.S. developments of the vast energy reserves of Siberia appear to be technically feasible and economically beneficial, but await political developments (some of which seem to be incipient) to move closer to actual implementation.

5.4.2 People's Republic of China

Japanese economic and political relationships with the People's Republic of China (PRC) have fluctuated throughout the past decade, and even at this writing, considerable ambivalence exists within the country as to the relationships that could be established. On the one hand, a large section of Japan's business community considers the PRC a natural market for Japan's goods and has long chafed under the U.S.-imposed restrictions on trade as the price for access to the American market and for maintenance of U.S. security forces in Japan. President Nixon's visit to the PRC, the so-called "Nixon Shock" in Japan, created a great turnabout which led to Prime Minister Tanaka's visit to the PRC a few months later. Initial steps toward diplomatic recognition and initiation of commercial relationships seemed incipient, despite continuing trade and a good commerce relationship with Taiwan. Joint development of China's energy reserves seemed to be a natural development, and Japan made appropriate overtures for joint ventures. The results, detailed in Appendix C, have been ambivalent. Although PRC is self-sufficient in oil with extensive proven reserves, and has a proportionally small industrial base, it needs foreign exchange, and Japan would appear to be a natural and willing market. An agreement was recently negotiated for deliveries from the Taching Field (near Harbin in Northeast China) beginning in 1974. Potential conflicts of interest with the offshore boundaries claimed by PRC and Taiwan (discussed below) have polarized ongoing discussions, and active joint exploitation of PRC petroleum for the benefit of Japan does not seem to be in the immediate future — although, as discussed in Appendix C, the possibility that the U.S. international oil firms are "fronting" for Japanese interests cannot be dismissed. No LNG activities are currently pending between the PRC and Japan.

5.4.3 United States

Japan and the U.S. are both partners and competitors in the search for global energy. Many Japanese-American petroleum joint ventures exist worldwide. In addition, Japanese industry has emerged as a prime supplier of sophisticated offshore drillships and drilling rigs, many of which are used by U.S. firms in joint ventures with other countries (e.g., Japanese rigs used by Philipps in conjunction with Norwegian partners in the North Sea). Japan is an eager potential consumer of U.S. oil from Alaska, and currently operates a sophisticated LNG liquefaction plant on the Cook Inlet which gives its total production to Japan. Japanese companies have joined in surveys in the Gulf of Alaska in anticipation of offshore leasing, and have cast covetous official eyes at the U.S. reserves on the North Slope. If the trans-Alaska pipeline terminates at Valdez (as is the current plan), pressure to sell oil to Japan would increase, but might be forbidden by pending congressional action.

In the area of direct competition, Japan and the U.S. compete for overseas oil from the Persian Gulf region. Although Japan desires to lessen her dependence upon the Persian Gulf, Japan has carefully refrained from endorsing U.S. policies toward Israel, and has done nothing to create any resentment in the Arab world. Japan has kept her options open by refusing to join with the U.S. in an anti-OPEC consumers union previously mentioned. Extensive dollar holdings and governmental backing puts Japan in a position to outbid the U.S., in a form of economic warfare, should supplies tighten. On the other hand, the possibility of Japan, the USSR, and the U.S. jointly developing Soviet energy resources creates an ambivalence in her position.

The U.S. holds another trump card in the energy stakes vis-a-vis Japan and that is immense, accessible reserves of high-grade coal. This option is further explored in Appendix B, but can be summarized, in an admittedly hypothetical situation, in which Japan takes a good hard second look at the utility of coal in her energy spectrum. When Japan converted the bulk of her thermal electric generation capacity from coal to oil in the 1950s she automatically moved from dependence upon an available domestic resource to almost complete dependence upon a foreign resource. At the time, low-price foreign crude was readily available, and shortages such as are now incipient were not foreseen. On the other hand, approximately 50 percent of the U.S. electrical power-base is generated by coal, and new power stations continue to consider coal a viable option as a thermal source. The technology to make coal burning power plants acceptable environmental neighbors is being pursued at speed; reintroduction of a coal burning, advanced-technology turbine-powered locomotive for the railroads is even being considered. Although technology transfer options are considered in the following section, the vast reserves of U.S. coal represent an important potential source of foreign exchange and an energy source that can be exported without serious impact upon U.S. energy requirements. The environmental issues, both in the extraction (e.g., strip-mining) and consumption of coal, are serious and should not be ignored. Japan will be reluctant to add to her already heavi. ... iuted atmosphere the outputs of multi-megawatt coal-fired thermal plants. But the technology is being developed to make the coal-fired thermal plant more environmentally acceptable. In August 1973, at least one projected nuclear plant in the U.S. was cancelled, and a coal-fired plant was projected as a replacement; at least one oil-fired plant has been reconverted to coal; and several advanced technology coal-fired plants have been projected for the next 2 years. A more serious environmental issue is strip mining in the United States; the quantities of ground that would have to be turned over to strip mining to supply Japan might be environmentally unacceptable.

5.5 Japanese Offshore Oil Development

Japan either singly or in joint ventures is actively pursuing oil exploration worldwide. In some areas, primarily in the exploration for offshore oil, geopolitical problems and possible confrontations may emerge. Geopolitical complexities have already arisen between Japan and the Republic of China (ROC) in which Japan is a primary participant, and may arise in areas where Japan has leased concessions: the Yellow Sea Basin is the primary focus; the concessions leased in disputed territory in the Gulf of Thailand present another; and new Vietnamese concessions also offer possible jurisdictional dispute. The discussions below summarize the results presented in Appendix C.

5.5.1 Yellow Sea and China Sea

Recent reconnaissance surveys suggest that large potential oil resources lie on the continental shelf of the Yellow Sea and the

East China Sea. On the basis of geologic and geophysical data, some estimates have compared the potential of the area to that of the Persian Gulf. Discoveries of oil in contiguous areas of the PRC tend to confirm these estimates. If such is the case, the stakes are enormous, and the potential for territorial confrontation is high. Based on such preliminary surveys, Japan, the ROC, and the Republic of Korea (ROK) have independently granted exploration concessions to foreign oil companies. Because of irregular coastal configurations, a large number of islands (some of which are claimed by one or more countries), poorly defined continental shelf boundaries, and the ambiguities of international law on the subject, the offshore claims of Japan, the ROC and the ROK overlap. Some of the territorial claims involve potentially prolific petroleum areas and serious confrontations are possible.

The following areas of potential territorial conflict exist in the Yellow Sea:

- ROK versus PRC both versus DRK (North Korea)
- ROK versus PRC
- ROK versus Japan
- ROK versus ROC versus Japan
- ROC versus PRC
- ROK versus ROC
- ROK versus ROC versus PRC

As can be seen, almost all the geopolitical permutations and combinations that are possible in the region exist. Two overlapping claims involving Japan are currently active: the Senkaku island dispute and the Korea Strait dispute.

5.5.2 The Senkakus

The Senkaku islands are currently the focus of much strong diplomatic language, and since the area lies in a promising oil zone it is a potentially serious problem. The Senkakus are a small archipelego lying between Taiwan and the Ryukyu Chain. They are claimed by ROC as part of Taiwan; they are claimed by Japan as part of the Ryukus. With the reversion of Okinawa and the balance of the Ryukyus to Japan, the problem reaches new and potentially more serious proportions. A major strike in the area could exacerbate the problem.

5.5.3 The Korea Straits

South Korea granted explorations concessions to an American firm to explore the Korea Straits in an area claimed by Japan, and in an area where Japan was both operating with Japanese firms and had granted third party exploration concessions. The problem seems to have been settled amicably by negotiation, in which sole jurisdiction was given in part of the area, and joint exploration concessions were given in the balance. Again, a major strike could negate previous positions.

5.5.4 People's Republic of China

Still to be heard from in the two previous disputes was the PRC who claims Taiwan, the Senkakus, and a 200-mile continental shelf zone. Concessions granted by the ROC for exploration in the East China Sea were declared invalid, and further exploration activities ceased. PRC also claims that the ROK-Japan settlement in the Korea Straits is invalid because of the PRC continental shelf 200-mile claim.

As has been previously mentioned, after an initial period of friendliness, PRC has remained cool to Japanese overtures for joint exploratory development in the Yellow and East China Seas. It can be hypothesized that Japan could well support territorial claims of nations opposing the PRC position to improve her own position.

5.5.5 Southeast Asia

Conflicting territorial claims in the Gulf of Thailand could well bring on confrontation if the area lives up to its promise as a continental shelf oil basin. The primary areas of dispute lie between Cambodia and Thailand, and are more fully detailed in Appendix C. South Vietnam also maintains claims in the area based primarily on border extensions of Islands in the Phu Quoc group. In early July, Thailand gave her claims the force of law by publication of the Royal Government Gazette, extending claims over areas claimed by Cambodia and South Vietnam. Concessions have been let by Thailand from Bangkok south to the Malaysia border. No major production or exploration well has been brought in at this writing, but the potential for serious jurisdictional problems exists.

Conflicting offshore jurisdictional claims also exist between Cambodia, Malaysia, and Indonesia; thus far they have been only of academic interest, but may burgeon if the oil potential of the area is realized. Japanese exploration and development is active in the area, and if production becomes justified, Japan may have a direct strategic and economic stake in this region.

Section 6

POTENTIAL IMPACT OF TECHNOLOGY TRANSFER

6.1 Energy Production Technology

Rather than approach the subject of technology transfer from the standpoint of the state of technology in various energy fields, we consider technology transfers in terms of their potential impacts. Japan is primarily dependent upon oil for her energy needs and with existing technology will remain primarily dependent upon oil through the remainder of the century. During this same time both the U.S. and Europe, given present technology, will need large amounts of imported oil. The potential for political instabilities, economic dislocations, or actual conflicts involving the major industrial nations in their competition for oil is certainly of real concern. Technology transfer which might lessen Japan's need for oil, therefore, would have the primary potential benefit to the U.S. of helping to maintain political and economic stability. Examples of such technology transfers include:

- Coal Utilization
  - Coal Gasification
- Direct Process Use of Nuclear Energy
  - High Temperature Gas Reactor Technology

- Geothermal Energy Use
  - Binary Fluid Heat Transfer System
  - Geothermal Detection Methods
  - Geothermal Stimulation
- Fusion Power Production
  - Fusion Feasibility
  - Fusion Engineering
  - Laser Ignition Fusion

Technology transfer in the fields of coal and nuclear energy would have the secondary advantage of increasing Japan's use of an energy resource which is abundant in the U.S. and which Japan could be expected to purchase in large amounts from the U.S. Technology transfers in these areas would thus be of significant economic advantage to the U.S. Technology transfers in the other areas indicated above would provide Japan with the means for using domestic potential energy sources and while some economic advantage might accrue to the U.S. in the selling of ideas and equipment, no continuing economic advantage from the selling of plentiful U.S. resources would be expected.

Technology transfers in the area of petroleum production and transportation have purposefully not been mentioned for a variety of reasons. First, Japan is in the forefront of the technology of petroleum transport and storage. Secondly, Japan has no real domestic petroleum resources so that drilling and production technology transfers would not have a significant impact on Japan's own energy resources. Further, Japan is already actively exploring for offshore oil and it is doubtful that any possible technology transfers would significantly impact Japan's discovery and exploration of offshore oil. Finally, Japan is already geared to using oil in all facets of her economy, with significantly better efficiency than achieved in the U.S., so that technology transfers in the use of oil are not apt to significantly reduce Japan's dependence on oil.

Another area of technology transfer which might have a major impact on Japan's future energy needs is the area of a hydrogen economy. Hydrogen is readily transportable via pipeline (at perhaps one-fourth of the cost of transmitting an equivalent amount of electrical energy), offers promise as a medium for buffer storage, is virtually non-polluting (only pollutants are nitrogen oxides when burned in air — none when burned in pure oxygen) and, of importance to Japan, can be used for the direct reduction of iron ore as supplies of coking coal become scarce. However, a hydrogen economy is not an energy source area but an energy storage and transfer scheme which is likely to develop as a consequence of the realization of an abundant and inexpensive energy source such as solar, wind or fusion power. Significant development of hydrogen economy technology, thus, is apt to depend on significant technological advances in other energy fields. The possible consequences of a hydrogen economy on Japan could be profound however. A cheap source of hydrogen could allow Japan (and other highly industrialized nations) to essentially completely substitute hydrogen for oil which would have a profound impact on the world energy picture. Thus, while it is still early to talk of developing the hardware which would be required in a hydrogen economy, studies on the feasibility and consequences of a hydrogen economy are probably needed now.

Comments on the specific areas of technology transfer mentioned previously are given below.

6.2 Coal Production and Use

U.S. technological capability and mining doctrine could be transferred to Japan to enhance the extractive efficiency from Japanese coal seams. Such transfer of technology could decrease labor requirements and increase productivity as well as allow the mining without human entry of seams which are now too dangerous to attempt by current, labor-intensive methods. However, Japan's coal resources are limited and distributed in thin, irregular seams so that while coal mining technology transfers will help increase Japan's domestic coal production somewhat, the overall impact in terms of reducing oil requirements will not be large. Coal gasification, on the other hand, could contribute significantly towards offsetting an increasing Japanese dependence on imported petroleum. Achievement of economical coal gasification in either the U.S. or Japan would provide both with a practical alternative energy source. Coal is abundant in the world, and the U.S. has the world's most extensive coal reserves. Achieving an economical means of coal gasification, therefore, would mean Japan could either import manufactured gas from the U.S. or could import coal and with transferred U.S. technology convert this coal to gas. Most industries in Japan presently using oil could easily convert to gas if an economical supply were available. Development of coal gasification could contribute significantly towards offsetting an increasing dependence in Japan and the U.S. on imported petroleum as a source of energy. Coal gasification could also put the U.S. in the position of an energy exporter.

6.3 Direct Process Use of Nuclear Energy

The Japanese have made a preliminary feasibility study of using reactors to produce high temperature process heat for direct use in industry. Achievement of this goal would free nuclear energy from the constraint of being usable only for the production of electricity, and could greatly expand the use of nuclear energy. Although the U.S. is not directly pursuing research in this field, it is producing high temperature gas-cooled reactors (HTGRs). The high temperature capabilities of the present HTGRs would have to be increased if they are to be employed for direct process use, but the background technology acquired in building HTGRs could help Japan in developing the very high temperature needed for direct process use. It should also be noted that in addition to helping Japan develop an alternative to oil as an energy source, the development of nuclear power for direct process use would give the U.S. an export market for a plentiful energy resource, uranium, just as coal gasification would allow the U.S. to export coal.

6.4 Geothermal Energy

Japan, as an area that is essentially volcanic, has extensive geothermal reserves that have long been considered a potential asset. Geothermal energy, however, has lagged behind more conventional means of power production, because of abundant and accessible coal and oil. A few experimental wells were drilled before World War II, but it was only during the post-war electric power shortages that the geothermal potential of Japan began to emerge as a viable asset. Small wells were drilled in the most potentially prolific zone in Kyushu, in the vicinity of the famous Oita-Beppu Hot Spring resorts. Output was disappointing, and drilling gave way to technology studies which emphasized improving the efficiency of steam-water separators.

Drilling technology advanced to the point where in 1961 additional productive wells were drilled in the same area, and a full-fledged geothermal power plant was placed online which produced 11,000 kw. Additional drilling in the same area is expected to yield a capacity of 50,000 kw by 1975. Drilling is also underway two kilometers to the south in another promising area where a potential of 250,000 kw is predicted.

Interest in geothermal development is ongoing in the United States where several advanced technology approaches to the problem are being investigated by both the AEC and the National Science Foundation. Planned research is concentrating on improved methods of extracting geothermal energy, improved methods of detecting, mapping, and overall exploring of geothermal fields, environmental impact of geothermal activities, and studies of possible seismic effects (of great concern in Japan). In the area of exploration techniques, the U.S. is pursuing methods of detection of potential geothermal fields where there is no surface expression (e.g., fumaroles or hot springs). Even though the existence of potential geothermal areas is known, the exact siting of geothermal wells, the depths to which to drill, and the expected rate of depletion of the geothermal reservoir are under active investigation in the U.S. and should be of interest to Japan. U.S. research on the use of binary-fluid heat transfer systems, permeability stimulation by hydrofracture, and remote sensing of thermal areas could be of great importance to Japan. Japan can also be expected to take an interest in research exploring the possible environmental impacts related to geothermal development particularly as regards land subsidence and induced seismicity.

6.5 Fusion Power Production

Achievement of practical power production from fusion power is not apt to occur within this century in Japan or any other country. Nevertheless, keeping the Japanese scientific community well appraised of U.S. efforts in the fusion field can only help to speed the development of fusion power. Since fusion power represents a nearly limitless source of energy, it appears in the interest of the world as a whole and certainly in the interest of industrialized nations such as the U.S. and Japan to develop a plentiful, clean source of energy such as fusion power. The U.S. is definitely ahead of Japan in the field of fusion research but has not yet demonstrated scientific capability. The transfer of technology in the fusion field, thus, involves not a transfer of proven technology but rather of ascertaining that scientific progress is disseminated to the worldwide scientific community so as to maximize the potential for achieving scientific breakthroughs. In the "classical" approach to fusion power employing magnetic fields to contain the fusion plasma, research in this country has been available to the scientific community as a whole for some time. However, much of the work done in the field of using lasers to ignite fusion has not been made generally available. In as much as the laser-ignition approach to fusion holds the promise of a quick breakthrough for the practical use of fusion power (laser ignition might bypass many of the difficult problems associated with magnetic field containment of plasmas), it would appear that efforts should be made to assure rapid scientific development by more open discussion of laser ignition in the worldwide scientific community.

6.6 Energy-Related Technology

In addition to the technologies discussed above which deal directly with energy production, there are several areas in which technology transfers in related fields might help Japan to continue to maintain her industrial growth. Examples include:

- Coal Sulfur Emission Control
- Uranium Enrichment Technology
- Radioactive Waste Disposal
- Environmental Technology

In the field of oil desulfurization, Japan already has very advanced technology while the U.S. leads in technology related to control of sulfur emissions from the burning of coal. Demonstration in the U.S. of practical sulfur control techniques for the burning of coal which may be achieved in the near future, and the transfer of this technology to Japan might convince Japan to burn more coal, particularly in the production of electricity. This would have two primary advantages: (1) it would provide Japan with an alternate energy source, and (2) it would provide the U.S. with a potential export market for her abundant coal resources.

Transfer of technology related to uranium enrichment would definitely prove an asset to Japan. The U.S. has had operating gas diffusion enrichment plants for several decades, whereas Japan has a rapidly expanding need for enriched uranium but no experience with enrichment facilities. However, at present the U.S. is the sole source for enriched uranium and providing enrichment facilities for Japan is of definite economic advantage to the U.S. Transfer of technology in this area, therefore, must be balanced between the desire to help Japan expand non-oil energy production methods, and thus lessen competition for oil with the U.S., and the desire to provide exports to Japan to maintain the balance of trade. It should also be noted that Japan, given her commitment to nuclear power in the future, feels a definite need to develop her own enrichment facilities sometime in the 1980s. It is likely, therefore, that even if the U.S. makes no attempt to transfer enrichment technology, that Japan will achieve her own capabilities in this area at some future date. Any transfers of technology in this area could, however, definitely influence the date at which Japan builds her own enrichment capabilities.

Disposal of radioactive wastes will become a growing concern to Japan as her nuclear industry expands. This is especially true given the probability of a worldwide ban on the disposal of radioactive wastes at sea, and the lack of appropriate geologic areas in Japan for the disposal of radioactive wastes. It will probably be of advantage to the U.S. to provide Japan with the means of disposing of radioactive wastes (this may include providing the actual disposal sites in the U.S.), both to insure that waste disposal problems do not threaten the Japanese nuclear industry and to insure that radioactive wastes are properly disposed.

There are other speciality areas related to minimizing environmental impacts in which technology transfers might help Japan maintain her growth. This is especially true in the nuclear industry. The U.S. nuclear industry has been facing for several years now environmental constraints which the Japanese nuclear industry is just beginning to encounter. In particular, in the areas of thermal pollution and radioactive releases, the U.S. nuclear industry has had to develop considerable technology in areas such as offshore floating power systems, cooling tower systems, and noble gas filter systems. Efforts could be made to assure technology transfers in these areas to prevent, as much as possible, the slowdown in nuclear growth which occurred in this country from happening in Japan.

REFERENCES

(1) Richard Ellingworth, "Japanese Economic Policies and Security," Adelphi Papers Number 90, The International Institute for Strategic Studies, London, 1972.

(2) Government of Japan, Ministry of International Trade and Industry, The Problems of Energy in Japan, Tsusho-Sangyo Kenkyusha, Tokyo, November 1971 (in Japanese).

(3) Kakuei Tanaka, Building a New Japan — a Plan for Remodeling the Japanese Archipelego, SIMUL Translation, 1973.

(4) Government of Japan, Office of the Prime Minister, Bureau of Statistics, "Statistical Handbook of Japan," Tokyo, 1971, (in English).

(5) Japan Consulting Institute, Report on CTS and Pipeline across South Thailand: Volume I, General Report, Tokyo, March 1972.

(6) Japan Information Service, Consultate General of Japan, "Japan Developing Overseas Oil Resources," Japan Report, Vol. XVIII No. 6, New York, 1972.

(7) Government of Japan, Ministry of International Trade and Industry, The Problems of Energy in Japan, Tsusho-Sangyo Kenkyusha, Tokyo, November 1972 (in Japanese).

(8) ________, Ministry of International Trade and Industry, "Combined Energy Statistics," Combined Energy Policy Department MITI, Tsusho-Sangyo Kenkyusha, Tokyo, 1972 (in Japanese).

(9) The Institute of Energy Economics, "Energy in Japan," Quarterly Report No. 19, Tokyo, December 1972 (in English).

(10) ________, "Long Range Forecast of Energy Demand in Japan, 1975-1985," Tokyo, 1972 (in English).

(11) T. Iwabe, Japan's Energy Outlook, Mitsui and Co., Ltd., Tokyo, 1972 (in English).

(12) Overseas Electrical Industry Survey Institute, Inc., Electric Power Industry in J. ` 1972, Tokyo, 1972 (in English).

(13) National Petroleum Council, U.S. Energy Outlook, Industry Advisory Council to the Department of the Interior, Washington, D.C., December 1972.

(14) Earl Cook, "Energy Sources for the Futu. :," The Futurist, Resources for the Future, Inc., Washington, D. C., August 1972.

(15) Herman Kahn, The Emerging Japanese Superstate — Challenge and Response, Prentice Hall, 1970.

(16) Sun Oil Company, Analysis of World Tank Ship Fleet, December 31, 1970, Corporate Development Group, Sun Oil Company, Philadelphia, August 1972.

(17) Oliver, Edward F., Capt. USCG., "Malacca: Dire Straits," Proceedings of the United States Naval Institute, Vol. 99, Number 6/844, Anapolis, Md., June 1973.

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